J. de Zielinski

HYGIENE

OF

THE VOICE

ITS PHYSIOLOGY AND ANATOMY.

BY

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NEW YORK:
G. SCHIRMER, 701 BROADWAY
1870.

THE TROW & SMITH
BOOK MANUFACTURING COMPANY,
46, 48, & 50 Greene Street.

TO

GENERAL C. C. DODGE

THIS MONOGRAPH IS INSCRIBED

AS A

TOKEN OF REGARD BY

GHISLANI DURANT.

These pages are not intended as a manual for singing; they make no claim whatever to any thing beyond what their title imports. In them I have sought to convey such a knowledge of the construction and mechanism of the vocal apparatus, as will enable the singer to know what he is making use of, so that he will only ask of each peculiar part that which it can perform, and not task it beyond its power.

For this reason, I have entered, more minutely than otherwise I could have done, into a great number of general considerations, both theoretical and practical, concerning the vocal organs.

To those who desire to pursue more fully the study of this subject, I would advise a careful perusal of the works of C. Beauquier, Brouc, Columbat, Ed. Fournié and Segond, whose experiments and conclusions, verified by my personal observations, form the basis of this monograph. G. D.

New York, Dec., 1869, 31 West 32d Street.

HYGIENE OF THE VOICE.

CHAPTER I.

SOUND.

PITCH . . . . INTENSITY . . . . TIMBRE.

THE natural phenomena which are incessantly developing themselves on our earth and in the vast space around us, offer to our view so magnificent a spectacle, that the curiosity of the most listless observer becomes powerfully aroused, and in spite of himself he is compelled, in a greater or less degree, to meditate upon the causes capable of producing such marvellous effects.

Ever since scientific men began to attempt the explanation of these natural phenomena, they have observed and collected a great number of facts, quite distinct from each other, which they have classified under such different heads as Light, Heat, Electricity, Sound, etc. We can easily distinguish these phenomena from each other, but when we attempt their explanation, to discover the causes which produce them, we are as much in the dark as we are in regard to the soul, or the vital principle.

The human mind, always prone to generalize and

to consider unity of means as perfection, went so far as to assign to heat, light, electricity, and sound—and with great probability of correctness—a common principle: vibratory movements or waves acting upon different organs; and asserted that the different sensations arose from peculiar conditions of relative motion among the elements of which our physical organizations are composed, the conditions of motion being determined by the internal state of the bodies with which we are in contact. May it not be true that the light which strikes the eye produces its impression upon the retina as heat, and that the sounds which strike the ear produce their impression upon the nerves of hearing as motion? It is the same cause which produces these effects, whether it is propagated through an imponderable fluid as the ether, or through the air, that is to say, vibration.

Indeed, we may go farther still, and say that, since matter manifests itself to us by all these different phenomena, which are after all but vibratory movements of the molecules of the body, transmitted to us as waves, it results of necessity that vibratory motion is an inherent quality of bodies.

For the mind which sees beyond external appearances, matter, from the very fact that we perceive it in some way, is always in motion. If a light is removed from our eye, so that we see it no longer, shall we say that the vibrations of the ethereal medium have ceased? If a sound descends from a tone excessively high to one so low that we are no longer able to hear it, are we justified in affirming that the sonorous body, or

that the air, has ceased to vibrate? Evidently not. Reason tells us, on the contrary, that the rest is relative only and not absolute, and that the body still vibrates, but that on account of the imperfection of our ear, we are only enabled to perceive those sounds whose vibrations have a certain intensity and rapidity, and that vibration may none the less exist in a sonorous body, although unable to produce an impression on the ear.

If, therefore, every thing is in motion, every thing vibrates, every thing resounds, there is only required a medium subtle enough to transmit, and an organ delicate enough to perceive, these vibrations in order that we might live in the midst of sounds, as we do in the midst of light.

Between light and sound, the analogy has often been made, and this in all ages has given birth to thousands of comparisons between musical tones and colors: between music and painting. That this analogy exists, is indisputable; but we must be on our guard lest we carry it farther than the nature of the case will allow. It is true that it may serve as a source of metaphor, but we must not claim for it any scientific value whatever. If, since the varying rapidity of vibration produces the different colors as well as tones, in considering the resemblance between music and painting, we should find that the number of vibrations corresponding to the red of the chromatic bears the same relation to the number corresponding to C of the acoustic scale as that for the orange does to that for D, or that for the yellow does to that for E, or even that the propor-

tion should hold good throughout both the chromatic and acoustic gamuts, nevertheless, we should not be justified in asserting, from this resemblance, that a complete identity had been established; and imagine that a harpsichord of colors might be constructed on which we would be able to play tunes with the eyes.

When we hear a musical scale executed, we need but listen to a few notes to perceive a difference in the *pitch* or *note* of the sounds.

But this is not the only difference we notice, for we know that two sounds alike as to their note may differ as to their volume, or the more or less decided impression they make upon the tympanum. We, therefore, have another characteristic difference besides the pitch—the *intensity* or *loudness*. But is *this all*? Can we not distinguish the difference between the sound of a fresh, girlish voice, and the rough, worn out voice of a street-singer? Or, to use the words of Laugel, "I wish to know why the sighs of the hautboy differ from the twang of the violin, from the blare of the trumpet, from the subdued sounds of the horn, from the soft nasillements of the bassoon; to understand why the varied stops of the organ differ; why its harmonies float from thunder-peals to sounds so sweet that they seem the flappings of seraphic wings; why its breath now thrills me through, and now caresses me as with invisible kisses?" There exists, then, a third character, or distinction of sounds, a character more definite, more decided than the other two, which may be called its physiognomy, its color, its perfume, and which the reader has already recog-

nized as the *timbre* or *quality*. We have now all the characteristic differences between sounds; two notes of the same pitch, of the same intensity, and of the same timbre are completely identical.

PITCH.

We all know that the pitch or note of a sound, whether it be acute or grave, depends upon the number of vibrations of the sonorous body in a given period of time, as during a second, for example. The highest or most acute sound would be the one produced by the greatest number of vibrations of which the ear could take cognizance, and consequently of the most rapid motion of the auditory nerves possible, while, on the other hand, the lowest or gravest note would be produced by the least number of vibrations capable of producing an effect upon the ear.

But, as we have already said, the sensibility of the nervous apparatus is limited. The number of vibrations must be comprised between given limits, in order that the sound produced shall be audible; should the number of vibrations be too great or too small, the resulting sounds would escape us. It has been found by experiments that the deepest or gravest sound audible to the human ear must be produced by at least from 7 to 15 vibrations per second, and that the sound becomes distinctly audible only when the number becomes some 64. On the other hand, the greatest number of vibrations producing the highest or most acute sound audible to our ear, cannot be greater than 30,000, and

this number makes a very disagreeable impression upon the ear.

We will not speak of sounds produced by some 65,000 vibrations in a second, for besides the difficulty of obtaining them, they are imperceptible to almost all human ears, though they are distinctly perceptible to certain animals, differently organized from us, cats for example.

But this is not all. Besides these sounds which escape the ear on account of the small or of the great number of the vibrations by which they are produced, that is to say, those which are too grave or too acute, we observe also that this same imperfection of the organ of hearing does not allow it to distinguish between two sounds which differ only by a small number of vibrations—although in reality one may be more acute than the other—so, if a cord be set vibrating, and then, by the application of a continued and gradually increasing force, the tension of the cord be augmented, the cord vibrates more and more rapidly, and the pitch of the sounds is increased, but by degrees which are inappreciable to the human ear, as may be easily demonstrated by experiment. But between the starting point, which we will suppose to have been a cord stretched by its own weight, and the extreme point of tension, where the cohesive force of the particles of which the cord is composed, is just sufficient to overcome the efforts of the tensile force to produce rupture, many sounds differing in pitch have been produced, and while the ear has not been able to distinguish one from the other, so insensible has the

gradation been; just as in the spectrum of the prism the eye is not able to distinguish the precise point where one color begins and another ends. Therefore, it has been found necessary to establish a line of decided demarcation between sounds, neglecting those which serve as transitions, and keeping those only which, possessing the most definite qualities, produce, consequently, the most distinct and agreeable impressions.

The arbitrary scale, or series of notes produced in this way, is called the gamut. The gamut is, then, nothing but a choice of certain intervals, and the particular name given to each step of the ladder indicates the moment at which a sound differs sensibly from another.

If the sounds of the gamut be made to succeed each other, it will be found that they do not all produce the same sensation of pleasure; some satisfy fully the ear, by imparting to the sensibility an idea of fulness and completeness; others excite, disturb, or cause a desire for a more clear, more easy transition, and require, in order that an agreeable impression may be produced, to be completed by one of the former. It is in that happy combination of different intervals, that resides the charm of melody.

INTENSITY.

The intensity of sound results from the amplitude of the vibrations, in other words, the intensity is the quantity of strength with which the body is set in motion; and, in order that intensity may be appreciated

by the ear, it is necessary that the vibrations should be transmitted in their varying amplitude to the tympanum, so that we might define intensity to be the varying degree of motion imparted by the vibrations to the nervous fasciculi. A very weak or grave sound is powerless to stretch the tympanum, or to agitate the nerves of the ear, while a very violent sound, that caused by the discharge of a cannon, for example, may rupture the tympanum, or produce grave disorders in the nervous mechanism of the ear. But between these two extremes there is room for a great variety of agreeable sounds, which music can vary ad infinitum, and by means of which it is enabled to produce its almost unlimited power over its listeners. What is termed expression, if we except a few means borrowed from the *timbre*, consists almost exclusively of the shades of intensity.

TIMBRE.

Until now, we have examined only the strength and the rapidity of the vibrations, but we have yet to consider their form, and reason tells us that here we shall find the explanation of the timbre or quality.

The different molecules of which bodies are composed, are not all disposed in the same way: when a vibratory motion is impressed upon the body, all the molecules of which it is composed describe orbits around their centre of rest, but their orbits of motion are differently disposed in reference to the direction in which the sound is propagated to reach the ear; some orbits having the plane of motion in the direction of

sound propagation, some at various angles; and these various motions are transmitted to the air and thus to the ear.

And still further, in consequence of that varied disposition of the molecules of a body which permits some of them to vibrate strongly, some feebly, whilst others remain almost absolutely at rest, it follows that a sound is always, or at least very often, mixed with accessory sounds which disappear in the principal sound. If the string of a violin be forcibly pinched, or set in motion by a bow, a delicate ear will detect at the same time, and like a slight emanation of the fundamental note, the third, the fifth, the octave, etc.

Habit enables us to isolate these sounds from one another. They are the elements out of which the science of harmonics is made up.

A sound, then, taken as a whole, is complex, just as the white light is, and just as the prism can separate sunlight into its primary colors, so a nice ear can distinguish, at the same time with the primary, the secondary sounds. Hence we have in the ear an infinite number of nervous cords, some of which are acted upon violently by the principal vibrations and give the chief impression of tone, whilst others, agitated more feebly by the secondary sounds, serve only to modify the principal impression; and it is for this reason, that any person, although he may not have a very delicate ear, easily recognizes the timbre.

We may, then, define the timbre to be the result of accessory sounds, *harmonic* when the sound is musical, *inharmonic* when it is a noise, and say that it varies

according to their number and pitch. Experiment has shown that, when the partial sounds change, the timbre also changes, and hence the explanation of the timbre: that as we modify either the molecular arrangement of the substance, or the substance itself which is vibrating, or the column of air which forms the conducting medium, we modify the orbital motion of the molecules, and therefore the accessory sounds; for *the timbre is nothing less than the form of the vibration of the air, reproducing itself exactly on the nervous matter of the ear.* (BEAUQUIER.)

CHAPTER II.

HISTORIC SUMMARY OF THE THEORIES OF THE FORMATION OF THE VOICE.

THOUGH a great number of theories have been successively advanced to explain the voice, its formation, and the various phenomena which it presents, yet they may be all classed under three principal groups. 1st. Those in which the vocal organ is compared to a wind instrument with an inflexible mouthpiece, as the flute, flageolet, or the organ-pipes; 2d. Those in which it is compared to a wind instrument having a reeded mouthpiece, as the clarionet, bassoon, etc.; and 3d. Where it is supposed to resemble a string instrument, or one partaking both of the character of a string and wind instrument.

A brief summary of the opinions held by some of the most eminent physiologists, of both ancient and modern times, will show this statement to be correct *

Hippocrates, 400 B. C., says: "Man speaks by the air which he draws in the whole body but especially in the cavities. Pushed to the exterior by the vacuum, the air engenders a sound, the tongue articulates by its clashings, intercepting it in the throat, and

* *See* Ed. Fournié's *Physiologie de la Voix et de la Parole.*

striking against the palate and the teeth, it makes the sound distinct."

Ninety years later, Aristotle defines the voice to be "a certain sound produced by a living body, for inanimate things have no voice." He compares the organs of the voice to a flute; the trachea being the body of the instrument.

Plato, 429 B. C., defines the voice to be "a rustling in the air reaching the soul through the ears."

Galen, 131 B. C., shows a far more intimate acquaintance with the structure of the vocal apparatus, for he states the thorax to be the bellows, or reservoir for air; the vocal chords, the sonorous vibrating body, by which the sound is produced, and the palate and mouth to correspond to the tube of a wind instrument, by which the sounds are modified,—the whole apparatus being considered by him as analogous to a flute.

In the 16th century, Jerome Fabricio, speaking of the vocal apparatus, says: "The general efficient cause of sound is a body capable of condensing, compressing, striking the air, and making it break forth." His description would make the vocal organ similar to an organ-pipe.

Mersenne, 1588, says: "The faculty or motive power of the soul is the principal and first cause of the voice in animals and has its seat in the tendons." However, Mersenne did not say whether he considered the vocal instrument as wind or string.

Claude Perrault, 17th century, says: "The voice is a sound of verberation, which the air enclosed in the chest excites in sallying forth violently, and in grazing

the membranes constituting the glottis, so that it shakes its parts, and disseminates its particles, the return of which causes an agitation in the air, capable of making an impression on the organ of hearing." He also classes the vocal organ with instruments of the flute kind.

Dodart, 1700, says: "The voice is a sound—sound is an effect of the air beaten violently—the matter of the voice is the air contained in the lungs, pushed from downward upward, from inside outside. The resounding of any sound, and consequently that of the voice, supposes the voice already formed, and is only the continuation of the sound. The glottis alone," said he, "forms the voice and all its tones." He compares the organ of the voice to a horn or trumpet.

Ferrein, in 1742, was the first who attempted to draw sounds from the larynx of the dead. "I approximated," said he, "the lips of the glottis, and blew with force into the windpipe; upon this the organ seemed to take life, and sent forth, I will not say a sound, but a loud voice, more agreeable to me than the most touching music." Ferrein considered the larynx as a stringed instrument, and compared it to a violin.

The great naturalist, Cuvier, compared the vocal organ to a flute, and looked upon the glottis as the mouthpiece of the instrument, the mouth as the body or tube, and the nares as the lateral openings.

Dutrochet, 1806, held "that the production of the voice was an active phenomenon, depending upon the vibration of the fibres forming the thyro-arytenoïdean

muscles; and that the vocal tube is supposed to have no influence whatever on the production of tones."

Despiney de Bourg, 1822, stated "That the sounds formed in the glottis undergo at that aperture great variations; to reach the outside they escape through the pharynx, a muscular canal susceptible of experiencing numerous changes, and able, besides, to modify these sounds; that canal may be compared by its influence to the gliding coulisse of a trombone."

Felix Savart, 1825, says, that "it is easy to comprehend the formation of the voice if we consider the vocal organ, composed of the larynx, the pharynx, and the mouth, like a conical tube in which the air is brought by a movement analogous to that taking place in the flute-stop of an organ."

Malgaigne, 1831: "The voice is a particular sound produced ordinarily by the passage of the expired air in the aerial tubes." His experiments led him to consider the voice as a reed instrument.

Richeraud, 1833, declared the voice to be "an appreciable sound resulting from the vibrations which the air, sent forth by the lungs, experiences in passing through the glottis." Richeraud holds a *juste milieu* among the opinions already given, for he considers the vocal organ at the same time both as a string and a wind instrument.

Bennati, 1833, believes "that it is not the muscles only of the larynx that serve to modulate the sounds in singing, but also those of the os hyoïdes, those of the tongue, and those of the superior, anterior, and posterior parts of the vocal pipe, and that without the simul-

taneous and proportionally combined work of these, the degree of modulation cannot take place."

Dr. James Rush, 1833, says: "All we know is, that the voice is caused by the passage of air through the larynx and cavities of the mouth and nose."

Magendie, 1836: "We understand by voice the sounds produced in the larynx, at the time the air passes through that organ, be it to enter the windpipe or to leave it." He makes the vocal organ a reed instrument.

Columbat, 1838, states: "The voice is an animal sound, living and articulate; of which the air is the material cause, and the glottis the efficient cause."

Dr. John W. Draper, 1850, says, that "articulation is effected by the motions of the tongue and other portions of the mouth; sound is produced by the glottis, speech by the mouth."

Müller, 1851, states, that "in the formation of the voice, the windpipe acts as a wooden pipe of like diameter would do."

Manuel Garcia: "The voice is formed by the periodical compressions and dilations which the air experiences when, on reaching the glottis, the latter, by alternate and regular movements, stops, or permits its exit."

Dr. John C. Dalton, Jr., 1859: "That when a vocal sound is to be produced, the vocal chords are suddenly made tense, and applied closely to each other so as to diminish very considerably the size of the orifice; and the air driven by an unusually forcible expiration through the narrow opening of the glottis, in passing

between the vibrating vocal cords, is itself thrown into vibrations, which produce the sound required."

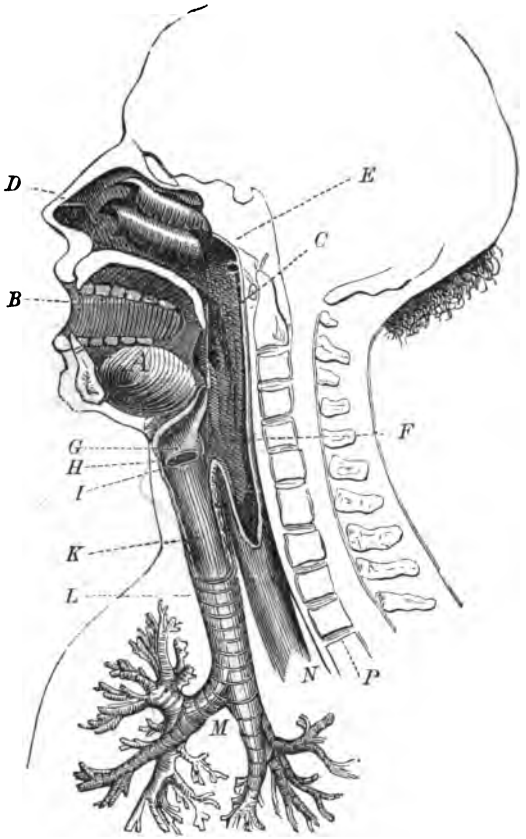
My views of the formation of the voice do not differ materially from those above mentioned. The vocal ligaments act in the same manner as two membraneous lips, which, as the air is forced up by the expiratory effort, are thrown into vibration, and thus produce the voice. This phenomenon requires the concourse of a great number of organs; the walls of the thorax, the lungs, the larynx and trachea, the mouth and nasal fossæ. However, the larynx alone essentially belongs to the voice.

Dr. Ed. Fournié, 1866: "The voice is a sound produced by a particular reed having walls modifiable under the influence of muscular action; the vibrating part being furnished by the mucous fold which limits the borders of the glottis. The vibrations are occasioned by the passage of the air through the glottis."

Dr. James Yearsley, 1866: "The term applies properly to the sounds produced by the action of the air on the vocal chords in the larynx."

Let us now pass from the summary of the various opinions held, concerning the mode of production of the vocal sounds, to the consideration of the anatomy of the individual parts, in order that we may understand clearly and appreciate fully the wonderful delicacy, simplicity, and beauty of the mechanism, which is one, if not the principal, means of communication between man and man, and which therefore affects not only his physical but also his mental condition.

Fig. 1.



A The Tongue.
B The Cavity of the Mouth.
C The Uvula and Soft Palate.
D The Nasal Fossæ.
E The Passage communicating with the Nose.
F The Pharyngeal Cavity.
G The Epiglottis.
H The Rima Glottis, or Opening of the Larynx.
I The Vocal Ligaments, or Corde Vocali.
K The Larynx.
L The Trachea, or Windpipe.
M The Bronchial Tubes.
N The Œsophagus.
P The Spinal Vertebræ.

CHAPTER III.

ANATOMY OF THE VOCAL APPARATUS

THE organs concerned in the production of vocal sounds are composed of three separate and distinct portions.

1st. The lungs (analogous to the bellows of an organ), and trachea, which furnish and convey the air necessary to produce the vibrations.

2d. The larynx, containing in its interior the vocal chords.

3d. The pharynx, mouth, and nasal anfractuosities, which serve to modify the sounds produced in the larynx.

I. THE LUNGS AND TRACHEA.

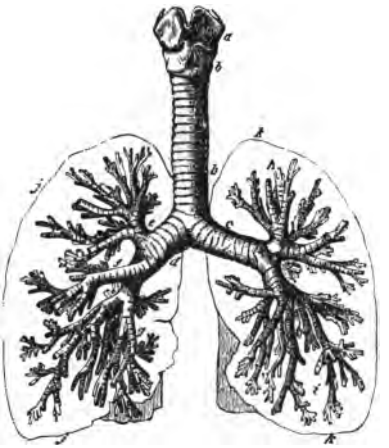
The lungs, the organs of respiration proper, are *two* in number, situated side by side in the thoracic cavity, surrounding the heart and occupying almost all the chest, except a very small space to the left of the median line where the heart may be felt to beat against the wall of the chest. They are separated from the abdominal cavity by the diaphragm, a sort of muscular membranous partition; their size varies with the capacity and condition of the chest, the age and sex of the

individual, the state of the health, and their condition at the time, whether of expiration or inspiration. They are conical in shape, the apex of the cone being directed upward; the right lung being shorter, but larger than the left, whose transverse diameter is somewhat shortened by the position of the heart. Their color is a light pinkish tint speckled with black.

The lungs are spongy in structure, and consist of air-vessels, air-cells or vesicles, nerves and blood-vessels, held together by the ordinary packing material of the body, cellular tissue, and are covered by the pleura, a shining membrane which is kept constantly lubricated so that they may move without friction or injury; the spongy character of the lungs is due to the air-vesicles.

If we examine the respiratory organs of any animal, the lights as they are commonly called, we find that the trachea divides into the bronchi, and these again divide and subdivide, diminishing in size till they become mere capillaries, losing their cylindrical shapes from the great number of air-vesicles (about $\frac{1}{100}$ of an inch in diameter), which open upon their sides, and finally terminate in one of these vesicles. A certain number of vesicles communicate directly with each other, and with a single branch of the bronchial tube, and are separated from neighboring air-cells by partitions of cellular tissue—parenchyma—and thus are formed the lobules of the lungs. We may, therefore, consider the lung as nothing more nor less than a collection of these lobules packed in cellular tissue, held together by the ramifications of the bronchi, which open in the midst of them, and thus put them into commu-

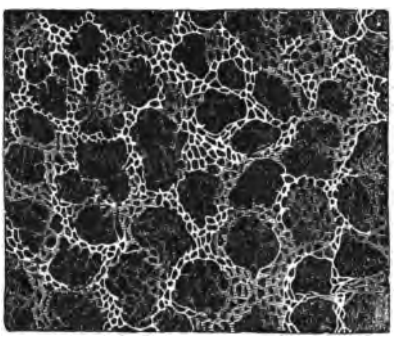
Fig. 2.



HUMAN AIR-TUBES.

The mode of distribution of the air-tubes is represented in fig. 2 (Draper's). *a* is the larynx; *b b*, the trachea, the upper letter corresponding to the cricoid cartilage; *c*, the left bronchus; *d*, the right bronchus; *e*, *f*, *g*, its ramifications in the right lung, *j j*; *h*, *i*, ramifications of the left bronchus in the left lung, *k k*.

Fig. 3.



DISTRIBUTION OF CAPILLARIES ON AIR-CELLS OF THE LUNGS.

nication with the external air, through the air-passages consisting of the trachea or windpipe, the bronchi, and their division.

Cruveilhier remarks that the size of the lungs, corresponding exactly with the capacity of the thorax, is therefore, like it, subject to variations; and as, on the one hand, the size of the lung is generally a measure of the energy of respiration, and, on the other, the energy of the respiration is a measure of the muscular strength, it follows, that a capacious chest, coinciding with broad shoulders, is the characteristic of a sanguine temperament and athletic constitution.

The *trachea* or *windpipe*, which carries the air to and from the lungs, is a cylindrical tube four or five inches in length, situated in front of the esophagus or gullet—which carries food to the stomach,—extending from the larynx above to the third dorsal vertebra below, where it bifurcates into the bronchi. It is formed of from sixteen to twenty cartilaginous rings, connected by ligamentous tissue of an elastic character; these rings are about two lines in breadth, and form the anterior two-thirds of the tube, but are deficient in the posterior third, which is completed by an involuntary muscular structure, whose fibres are placed transversely and which are possessed of much elasticity, to allow for the distension of the esophagus while the food is on its way to the stomach. The object of the rings is to prevent the falling in of the walls of the trachea during inspiration, and so to allow of the free access of air. The first ring is the largest, and the last is of such a shape as to be adapted to the first rings of the bronchi.

The bronchi are essentially of the same structure as the trachea, except that the rings are complete; the right bronchus is shorter, but of a larger diameter than the left; these soon ramify into numerous subdivisions which finally terminate in the lobules of the lungs.

II. THE LARYNX.

The larynx, the upper portion of the air-passages, is situated at the upper and anterior part of the neck, between the base of the tongue and the trachea, with which it is continuous below, and in front of the membranous canal which conducts the food to the stomach.

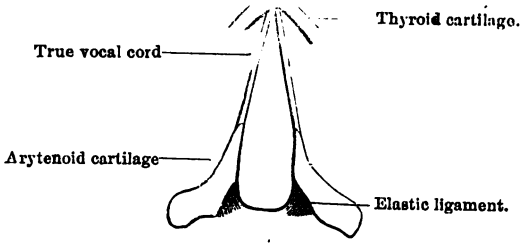
The larynx is narrow and cylindrical below but larger above, where it presents the form of a triangular box; it is formed of cartilages connected by ligaments moved by numerous muscles, lined by mucous membrane and supplied with nerves and blood-vessels.

The cartilages forming the larynx are nine in number, viz.:

the thyroid,	the epiglottis,
the cricoid,	2 cornicula laryngis,
2 arytenoides,	2 cuneiform.

The *thyroid* (from Gr. θυρεος ειδος, like a shield), is the largest of these cartilages and the one forming the greater portion of the larynx. It consists of two quadrilateral plates or lamellæ, united in the median line in front at an angle of about 70°, forming the pomum Adami, or Adam's apple. It forms the upper and anterior portion of the larynx, but is opened behind.

Fig. 4..



SHAPE OF THE GLOTTIS WHEN AT REST.—[H. HOLDEN.]

Fig. 5.

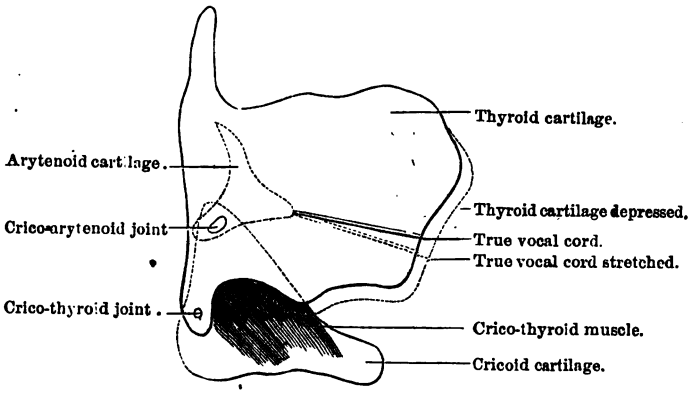


DIAGRAM SHOWING THE ACTION OF THE CRICO-THYROID MUSCLES.

The *cricoid* (Gr. κρικος ειδος like a ring), shaped like a seal ring, is placed horizontally below the thyroid, and above the trachea, and has its narrow portion in front, the wider behind, and fills up the posterior opening of the thyroid; it forms the base of the larynx. Its superior or upper border unites by means of a membrane with the inferior border of the thyroid and arytenoid cartilages; inferiorly it corresponds with the first ring of the trachea or windpipe, of which it seems a continuation.

The *arytenoides* (Gr. αρυταινα ειδος, ladle-shaped), are two small prismatic or pyramidal-shaped cartilages, standing in the open space of the thyroid, and upon the posterior portion of the cricoid, and united by their anterior borders to the posterior border of the preceding, and are therefore in the upper and back portion of the larynx. Their base is broad and concave, and articulates or unites with the cricoid, and is terminated by two apophyses, the posterior or external, and the anterior or internal; to the former are attached the lateral and posterior crico-arytenoid muscles, while to the latter, and the depression between the two alæ of the thyroid cartilage, are attached the inferior or true vocal chords.

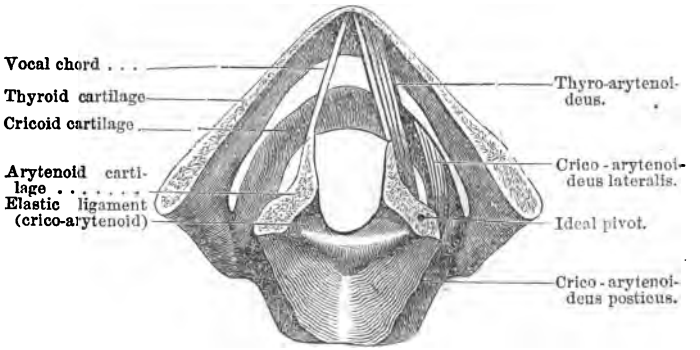
The *cornicula laryngis* and the *cuneiform cartilages* are not necessary to us to appreciate the mechanism of the voice. The former are cartilaginous nodules situated at the apices of the arytenoides; the latter small elongated bodies situated at the side of the arytenoides.

Finally we have the *epiglottis*, a thin leaf-shaped fibro-cartilaginous plate, situated behind the root of the tongue, at the superior portion of the larynx; its function is to oppose the passage of alimentary substances into the trachea and to modify the sounds as they leave the glottis.

Suspended as the larynx is to the *hyoid bone* (a horseshoe-shaped bone situated at the base of the tongue, with its rounded portion in front), it ascends and descends with it, and in order that it shall concur in both phonation and deglutition, it must execute certain movements as a unit, and to enable it to do this, the several parts of which it is composed are united by means of fibrous and membranous ligaments. Thus between the thyroid and cricoid we have the crico-thyroid ligament; between the thyroid and arytenoid, the thyro-arytenoid ligaments.

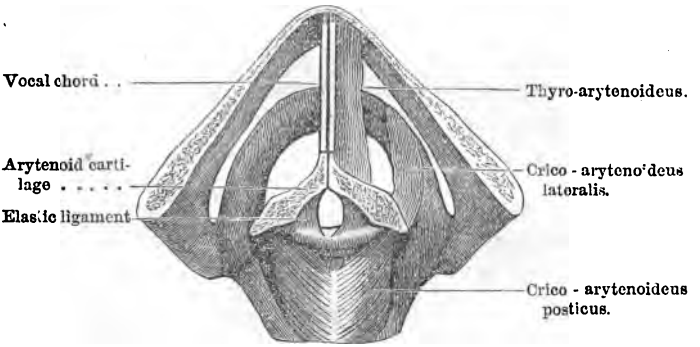
Thus far we have examined the formation, position, and exterior portion of the larynx; now let us examine its interior arrangement and strive to learn its functions and their modus operandi. First, we have the superior orifice, an oval space bounded in front by the epiglottis, behind by the arytenoid cartilages, and on the sides by folds of the mucous membrane. Below this and toward the middle of the larynx, we observe an oblong triangular slit between two membranous folds, which are stretched horizontally between the receding angle of the thyroid and the two internal apophyses of the arytenoides; these are the inferior or true vocal chords; so called to distinguish them from two other folds of membrane placed

Fig. 6.



GLOTTIS DILATED. MUSCLES DILATING IT REPRESENTED WAVY.

Fig. 7.



GLOTTIS CLOSED. MUSCLES CLOSING IT REPRESENTED WAVY.

parallel to and above them, which are called the superior or false vocal chords, since they do not, as far as has been ascertained, contribute in any way to the formation of sounds; on either side, between the true and false vocal chords, are two oblong fossæ called ventricles.

The *glottis* is a small elliptic or linear opening according to the moment at which it is observed, which separates the true vocal chords, or lips of the glottis, through which the air enters and leaves the lungs.

The two inferior or true vocal chords consist essentially of the thyro-arytenoid muscles covered by strong fibrous bands (inferior thyro-arytenoid ligaments) which in turn are covered exteriorly by a thin membrane; they are about two lines in width, and from eight lines to an inch in length; they are attached in front to the depression between the two alæ, or wings of the thyroid; behind, to the anterior angles of the arytenoides; and at the sides, to the thyroid, by the lateral attachment of the muscles. These ligaments with their covering are so attached, both in front, behind, and on the sides, that we may well assert they are incapable of vibrating so as to produce vocal sounds; but this exterior envelope (the vocal membrane of Dr. Ed. Fournié), is a very fine, transparent, and highly elastic membrane, so arranged on the interior border of the vocal chords that the slightest breath is sufficient to set it in motion. This membrane surrounds the vocal chords as a well fitting glove does the hand, and may be readily detached from the interior border of the chords, but adheres more closely to their body.

The movements of the cartilages of the larynx are performed by means of nine muscles, of which eight are in pairs, viz., the crico-thyroidei, the crico-arytenoidei postici, the crico-arytenoidei laterales, and the thyro-arytenoidei; and one single, the arytenoideus.

The crico-thyroid muscles are inserted partly into the anterior face of the cricoid, partly into the inferior border of the thyroid; they approximate the anterior portion of these two cartilages more closely. By this motion, the thyroid is made to recede from the arytenoid cartilages, and thus the vocal chords are stretched between them.

The posterior crico-arytenoid muscles extend from the lateral portions of the cricoid to the posterior apophyses of the base of the arytenoid cartilages. These muscles, when contracted, tend to carry the arytenoid cartilages, and the vocal chords attached to them, outward toward the cricoid, and consequently dilate the glottis.

The lateral crico-arytenoid muscles extend from the lateral portions of the superior borders of the cricoid to the posterior apophyses of the arytenoid; by their action they draw together the internal apophyses of the ayrtenoid cartilages, and therefore approximate the true vocal chords, and so narrow the glottis.

The thyro-arytenoidei arise from the inferior third of the receding angle of the thyroid, and are inserted into the internal apophyses of the arytenoid; their greater fasciculi are lodged in the texture of the vocal chord itself; they elevate the front of the thyroid, draw

it toward the arytenoid, and thus relax the vocal ligaments.

The arytenoid muscle extends from one to the other arytenoid cartilage, being attached to the posterior and external portions; its action is to approximate these cartilages, and consequently to constrict the glottis.

Finally, the larynx is supplied with a number of small glands, concerning the function of which but little is known; their use seems to be to secrete a mucus, which lubricates the larynx and epiglottis, keeps them moist and soft, so that motion shall be attended with as little friction as possible, and prevents irritation by the constant passage of air to and from the lungs during inspiration, expiration, singing, or speech; they are, the epiglottics, the subglottics, the arytenoid, and the ventricular. There are none on the vocal chords. The arteries are derived from the laryngeal branch of the superior and inferior thyroid. The veins empty into the thyroid veins. The nerves are the superior and inferior or recurrent laryngeal; the superior or sensor supplies the mucous membrane and crico-thyroid muscles; the inferior laryngeal, the remaining muscles. The arytenoid is supplied by both.

III. THE PHARYNX.

If you inspect some friend's throat, or your own, by means of a mirror, you perceive the opening into the throat—the isthmus of the fauces—the posterior wall of which is formed by a contractile surface, lined with

mucous membrane. This is the *pharynx*—the buccal face of the *velum palate*, or soft palate, which forms an incomplete partition between the mouth and the pharynx—in the median line a small, pendulous, conical body, the *uvula* or hanging palate—extending from the base of the latter, right and left, two folds of membrane forming an arch; these are called the *pillars* of the soft palate, they bound on either side a small cavity, in which is lodged the *amygdale* glands or *tonsils*.

The other parts which make up the organs of sound are the mouth and nasal fossæ.

The *nasal fossæ* are two irregular shaped cavities separated by a thin partition, situated in the middle of the face, and extending backward. They open by their anterior orifice upon the face, while their posterior opening is on the pharynx; they communicate with four sinuses, or cavities in bones, the frontal, sphenoidal, ethmoidal, and maxillary—the particular use of which will be explained hereafter; they serve to increase the dimensions of the vocal pipe.

The *cheeks*, during phonation, are almost passive, yet, being under the control of the muscles of the mouth, they may dilate or contract the buccal cavity, and so increase or diminish the size of the vocal organ.

The *mouth* plays a very important part in the modification of sounds, since it is formed of parts extremely movable, and therefore well suited, by the disposition and movements of its parts, for forming the particular cavity best suited for the special sounds; besides which it imparts a particular sonorousness to the voice.

The *lips*, by being projected forward or drawn backward, lengthen or shorten the anterior-posterior diameter of the buccal cavity, and so increase or diminish the length of the vocal pipe, and by their contraction regulate the size of its opening.

Finally, to terminate these dry details of anatomy, already too long, we have to mention the *tongue*, which of all parts of the mouth is most essential in modifying the vocal sounds, since it forms by its various positions the vowels and consonants, or increases or diminishes the buccal cavity.

CHAPTER IV.

FORMATION OF THE VOICE.

We have already studied the anatomy of the parts concerned in the production of voice; we have now to inquire what is the operation of the vocal apparatus in order to produce sounds; and, to understand this, it is necessary to advert to the condition under which notes are produced by instruments having some analogy to the larynx:—these, as we have already seen, may be divided into three kinds, strings, flutepipe, and reeds.

Ferrein, long ago, compared the vocal ligaments to vibrating strings, and, at first sight, there seems to be a considerable resemblance between them, the pitch of the note in both being high or low, according as the tension of the cord is increased or diminished. But on accurate observation this resemblance disappears, for we may easily satisfy ourselves by experiment that no string as short as the vocal chords could give a clear note as low as the middle notes even of the human voice; again, the changes produced by tension are very different. In a vibrating string, the number of vibrations are to each other as the square root of the extending weight. Thus, if a string be stretched by a

weight of 1 lb., and again by a weight of 9 lbs., the number of vibrations will be as 1 to 3, or the last note will be the 12th above the 1st. Müller has shown that this condition does not hold in the larynx, that the sounds produced by a variation of the extending force do not follow the same ratio; finally, although a string adapted to perform the lowest note of the human voice may, by increased tension, be made to produce all the higher ones, yet it does not follow that one which, with moderate tension, as in the vocal ligaments, produces a high note, can be made to produce all the lower notes by diminished tension, for the vibration becomes irregular from diminished elasticity. We see this in the case of the violin and violoncello, the long strings of the latter being necessary for the production of a good bass note.

The next class of instruments with which it might be compared is the flute. Here the pitch of sounds is determined almost entirely by the length of the vibrating column of air, though the sound is modified slightly by the diameter of the column and the kind of embouchure or mouthpiece. Here we find the pitch to be in inverse proportion to the length of the pipe, so that of two pipes, one being twice as long as the other, the shorter pipe would give a note an octave higher than the other, the vibrations being twice as rapid. The length required to produce the lowest G of the ordinary Bass voice is nearly 6 feet—so that there is nothing in the form or dimensions of the larynx and mouth which render it capable of producing the vibrations required for the tones of the voice.

We have now to consider the third class of instruments, those having a reed or tongue. These reeds may be elastic in themselves, or be made elastic by tension. We have two kinds of reed instruments, those having a "free" reed, as the accordeon, harmonium, etc., and those having a reed and pipe, as the Bassoon, Hautboy, etc. In the former, the pitch of the note is dependent entirely on the elasticity of the reed; in the latter, upon the elasticity of the reed and the length of the tube.

The researches of Weber are of great importance in determining the true nature of the vocal apparatus. He found, 1st. that the pitch of a reed could be lowered, but could not be raised by joining it to a pipe. 2d. The sinking of the note is not more than an octave. 3d. The fundamental note of a reed could be lowered by lengthening the pipe, but again restored by a further lengthening, and again lowered by a further increase. 4th. The length of tube necessary to change the pitch of the note depends upon the relation between the number of vibrations of the reed and the number of vibrations of the column of air in the tube. . . .

From these considerations and the preceding paragraph, we see that if the tube may be made to yield tones of any depth by prolonging it, the embouchure being the same, it must be considered as a flute; but if it can be lowered only an octave or less, with the same embouchure, it must be classed as a reed;—the latter is the case with the larynx.

We now see what is the true character of the vocal apparatus, that the sound is the result of the vibrations

of the vocal ligaments, and that these vibrate in the same manner as the reed of any musical instrument, and that the pitch is chiefly governed by the tension of the vocal chords. As yet we know little concerning the mode in which tones are modified by the air-passages, both above and below the larynx, but that they are so modified there can be no doubt, if we observe the great amount of muscular contraction taking place during singing or speech.

The production of a note presupposes two indispensable conditions: 1st, a body capable of vibrating; 2d, an agent, competent to produce these vibrations.

The first condition we have seen fulfilled in the larynx, which contains the chordæ vocales. The second, in accordance with that beautiful provision of nature that nothing shall be useless, we find in the air introduced in the lungs, and which having undergone change, has therefore become a waste product.

The mode of producing sound in the larynx is as follows: as long as the vocal chords retain their usual relaxed condition during expiration, no sound is heard, except a faint whisper as the air gently passes the cavity of the larynx; but when a sound is to be produced, the vocal chords are suddenly made tense and drawn parallel (for when they diverge ever so little, no sound is produced), and applied in close proximity to each other, whereby the size of the orifice is greatly diminished; then the air, driven by an unusually forcible expiration past the vocal ligaments, sets them in vibration, and in this manner vocal sounds are produced. The tone, pitch, and intensity of this sound

vary with the conformation of the larynx, the degree of tension and the approximation of the vocal chords, and the force of the expiratory effort. The narrower the opening, and the greater degree of tension of the chords under ordinary circumstances, the more acute the sound produced, while a less degree of tension and wider opening produce a grave note. To have some conception of the variety and delicacy of the motions necessary to the adjustment of the vocal C, listen to some singer whose voice commands with ease a great extent of the scale. For every note there is a particular adjustment of the vocal chords. It is calculated that in man the ligaments vary in length about $\frac{1}{5}$ of an inch, and in woman $\frac{1}{8}$. Now, the natural compass of most singers is about two octaves, or 24 semitones. Between each semitone an ordinary singer can sound 5 or 6 distinct notes, so that 120 would be only a moderate number of distinct sounds. He, therefore, produces 120 different states of tension, and as the extreme variation is only $\frac{1}{5}$ of an inch, the variation required to pass from one note to another, is but the $\frac{1}{600}$ of an inch.

A very expert singer can produce a much more delicate action than this. The celebrated Madame Maria, whose voice ranged through three octaves, could, it is said, produce between each tone-sound 100 different intervals, or 2,100 in all, so that she could determine the contractions of her vocal ligaments to nearly $\frac{1}{17000}$ of an inch.

The quality of the voice is also modified by the length of the column of air included between the glottis

and mouth, and that in the trachea, the tense or relaxed condition of the walls of the pharynx and fauces, and that of the nasal anfractuosities and the state of dryness or moisture of the mucous membrane lining aerial passages.

Articulation, or that modification or division of vocal sounds producing vowels and consonants, is accomplished by means of the tongue, teeth, lips, nasal passages, and fauces.

THE MALE AND FEMALE VOICES.

When we compare the male and female voices, we notice at once a great difference between them, yet the mechanism concerned in the production of the female voice is absolutely the same as that in the male. We find in both the larynx, lungs, and air-passages constructed in the same manner, and the same registers, chest, mixed, and falsetto. It is in the more or less frequent use of one or the other of these registers that one of the principal distinguishing differences between the male and female voice exists; for whilst man produces his most beautiful effects with the chest register, woman possesses but few notes in that, but sings especially in the mixed register.

The pitch of the vocal instrument of the male differs essentially from that of the female. Though vocal music is written in the same way for both, though there are the same notes, the same staves, yet the same note executed by a man will not have the same value when

executed by a woman, and when both sing the same piece, the woman always sings an octave higher than the man. This would lead us to suppose that the vocal instrument of woman was but one half the size of that of man; but this is not the case, that of woman being one third only smaller; consequently we must seek some other cause to explain this difference. This is found in the nature of the tissues composing the vocal parts, their thickness and rigidity having a great influence upon the note produced. In woman we find them thinner, more elastic than in man, especially the vocal membrane which leads to the production of sounds of a more acute pitch.

Though the voice of woman is less harmonic than that of man, yet it possesses a peculiar sweetness, and soft sonorousness which that of man does not. This has been well described by Gerdy; "Woman's voice is less strong than that of man; it is a charm which nature has given her to move us, to soften, to seduce us, to conquer and subjugate us; it seems as if the fibres of our heart were always in its unison."

Woman's voice is less strong, less intense than that of man. This seems due to the smaller size of her vocal apparatus. The thoracic cavity of woman is less spacious and the muscles which move it less strong, hence there is a less quantity of air set in motion; on the other hand her voice is softer and sweeter.

As to the range of the voice it is almost the same in both sexes.

DEVELOPMENT OF THE VOICE.

The wailing of the new-born babe is a squalling disagreeable cry which indicates to us the suffering of which it is the expression. Indeed, the babe only makes itself heard to express a want, a suffering. The wailing of the child is the cry of pain, it is painful to listen to and excites painful sentiments. Its squalling, disagreeable character may be accounted for by the fact that the vocal pipe possesses none of the elements necessary to modify advantageously the sounds produced by the larynx. The mouth presents too small a cavity to produce a harmonic resonance of the voice; the other parts are also but imperfectly developed, and it has not as yet learned the use of the muscles which modify the parts.

Voice is the principal means of communication between the parent and child, and its development is always in proportion to the necessities of the latter. In the first periods of life the child is only related to society by the material assistance derived from it. To sustain life and to develop its body are its only wants, and for their expression the monosyllabic cry suffices.

As the child grows, sounds little by little lose their disagreeable character, but they do not acquire the soft sonorousness of the developed voice, until the little being by a few words shows the first operations of its mind.

When about a year old children begin to proffer a few monosyllables; but what ravishing harmony do not mothers find in them! From this period until

they are 6 or 7 years old development of the vocal organ is much more connected with intellectual than with organic life. Speech now becomes the means of developing and perfecting the voice.

The development of the voice requires the most assiduous attention, and it is in youth that the vocal education must begin. We must strive, by every possible means, to obtain all the modifications of which an instrument, so admirable and so precious as the voice, is capable. Too great attention cannot be paid to the cultivation of the articulate voice. Children should be made to read aloud, pronouncing rigorously all the syllables, and so managing their voice, as to give the exact meaning of the phrase. They should avoid breathing too often or too abruptly, which might occasion a kind of hiccup, determining an irritation of the mucous membrane of the vocal chords, and so produce a hoarseness difficult to overcome.

Having educated the hearing of children so that they will enjoy music, and taught them to open their mouth, and to give it the form most favorable to the production of the particular sound desired, the next step will be to make them execute very slowly, not entire scales as is ordinarily done, but only the notes which they are able to produce without effort. This exercise should be repeated daily, but should not be continued longer than a quarter, or at the most, a half hour, according to the constitution of the child, lest the powers of the wind chest should be too strongly taxed.

If this plan be followed, the muscles will learn to

contract spontaneously under the influence of the will, and gain strength, and power of executing different notes readily and with ease.

This strength and power of execution is precisely what is wanting in people who have learned to sing late in life, since muscles left until they have attained their full development in inaction, oppose greater resistance to the will than those which in youth have been trained to obey it.

It is also of the greatest importance that young people should not be allowed to sing pieces not completely within the range of their voice, nor to strive to reach certain notes by too great nor too prolonged efforts, lest they should lose whatever disposition they may have for singing. If the attempt to execute certain musical compositions can alter, or even destroy, voices already formed, would they not, if they did no worse, prevent the development of vocal organs, yet young and delicate?

Until the age of 13 or 14, the voice of the young girl differs but little from that of the boy; but from this time they begin to change. The boy's voice is to become that of a man; the girl's that of a woman. The time at which this change begins is the age of puberty.

Until puberty, man has lived for himself alone. To develope his organism has been almost his sole care; but having arrived at that period, eloquent signs indicate that a great change is about to take place in his organism. A new function is to be established, and henceforth man can produce a being similar to himself.

The modifications of the voice, which occur always at that time, is one of the chief symptoms of the setting in of the generative function; and it is to this modification that the term *vox rauca*, change of voice, the "*la mue*" of the French, has been applied.

Girls generally develope more rapidly than boys. They arrive at the age of puberty, and become old sooner. Hippocrates attributed this to their more delicate organism, and to their mode of living. We find also that a variety of causes influence the age of puberty; the climate, for we find it earlier in warm than in cold climates; the mode of living, for it is certain that puberty develops itself earlier among the wealthy than the poorer classes; the theatre, the reading of novels, or any cause which, exciting the sensibility, provokes and accelerates the movements of nature.

This transformation is not always easy, sometimes being felt painfully, both in the physical and moral life of the woman. Yet sometimes it is effected in an almost inappreciable manner. The pitch lowers one or two notes, and the voice gains in strength what it has lost in acuteness. But if at that time she uses her voice much, she exposes herself to sore throat, or even loss of voice, occasioned by the exaggerated physiological work, which, at this time, the larynx is forced to undergo.

As we have said, the change occurs later in boys than in girls. The young man knows not the painful trials that await the young girl; he goes through the change almost unconsciously, except that the voice becomes modified.

These modifications vary very much as regards the sensible phenomena which they present, but there are two modifications common to all and entirely characteristic: 1st, the modification of the timbre; 2d, of the pitch.

The timbre, which gave to the boys the singing qualities of the voice of the young girl, changes completely its character; the pitch is sensibly lowered, and little by little the voice acquires those qualities which distinguish the male voice. Sometimes, about the age of 14 or 15, this alteration takes place insensibly, but more often, especially in those children who sing, it is accompanied by exaggerated manifestations of the change; the voice becomes harsh, and uneven; the boy loses the control of his vocal chords, and often emits a high note when he desires to sound a low one, or reversely, or even there is complete aphonia or loss of voice.

The phenomena to which we have just alluded, do not follow any very regular order of development. Generally the voice does not fail all at once. It is veiled, sometimes hoarse, the hoarseness continuing during the whole period of the change of voice, and the pure timbre only being regained after the lapse of six months or a year.

After a lapse of time, varying in different individuals, the young pubescent has lost entirely his child's voice; but that which he now possesses has not yet the strength, energy, timbre or pitch which are to characterize it; it vacillates between what it has been and what it will be. This is due to the fact that the larynx

has not as yet acquired its full development; the growth of that organ taking place slowly, and not being completed till 18 or 20. It may, then, be said, that the period of the change of voice in man varies from 3 to 5 years, and in woman 1 or 2 years less.

It is not necessary that the young pubescent should stop singing as soon as *vox rauca* appears. Most music teachers are in the habit of suspending all exercises, and even to forbid their pupils to sing at all. Although it is necessary to take the greatest precaution, lest the exercise should produce a weakening of the vocal organs, and therefore an arrest of development; nevertheless, I do not hold to the opinion of these masters; but, on the other hand, I believe that the exercises should be continued, even *during* the vox rauca, always taking care to make the pubescents sing with the greatest caution, practising not more than a quarter of an hour a day, and confining the exercises within an octave and a half, making no attempt to produce either the highest or lowest note, which he could previously sing. Another general rule is, to study carefully the voice of the pupils, to observe every day the notes they have lost, or are not able to sing easily, and to take them off from their exercises. Finally, there will be an epoch of very short duration, when the compass of the voice will be only an octave. During this time only would I advise a complete suspension of all vocal exercises. These may soon be resumed, proceeding gradually to add notes to the exercises in proportion as the voice gains in strength and range.

If these rules be followed, instead of being inter-

fered with, the physiological change of the voice will be hastened; the voice will be better developed, will have more strength, a greater range and more suppleness than if left to itself. If, however, hoarseness comes on at any time during the change of voice, all practice must be given up, and the pupil should be warned against all screaming, loud bursts of voice, or any thing else tending to increase the irritation of the vocal membrane.

After puberty, the larynx of the young woman continues to develope until she is 22 or 23 years of age, and that of the young man until the age of 24 or 25. The voice follows the development; it insensibly acquires greater strength and range until the moment when the organ has ceased to grow. From that time, no further change takes place in the voice, except that produced by study and exercise.

The remark of Dr. Fournié, that it is very difficult to determine the precise moment at which old age begins, will be found quite true, if we judge only from external appearances, for some persons possess the happy privilege of preserving all the outward signs of maturity, far beyond the ordinary limits. Years alone do not make the old man. It is rather the transformations taking place in the organism, one of the leading characteristics of which is the change occurring in the voice.

In woman one of the distinctive phenomena is the greater or less amount of congestion which takes place, and which sometimes produces hoarseness, and always a lowering of the vocal pitch; the timbre of the

voice changes little by little; its soft sweetness disappears, and finally it becomes very similar to that of man.

These modifications follow closely and seem to be connected with, if not dependent upon, the same causes which produce the suppression of the menses. It seems as if nature having given to the voice of the girl power to express the part she is called to play in the great function of reproduction, wished to point out by this modification that her ability to perform her part no longer exists.

The changes in the voice are dependent upon organic modification in the larynx. The mucous membrane lining it becomes of a more intense reddish tint; the circulation in the part is more active; and sometimes even polypoid growths are developed upon the vocal chords. These membranes always thicken, the cartilages become harder, and a sensation of uneasiness rather than of pain is experienced.

These changes are not so strikingly manifested in man as in woman. Although there is often a perceptible hoarseness, the modifications follow each other so insensibly that they are scarcely noticed. Probably the first phenomena noticed are the growing weakness and lowering of the pitch of the voice; he can no longer produce all the notes he formerly could by the chest register, and remedies that want of power by the use of the falsetto.

CHAPTER V.

REGISTERS.

A GREAT variety of opinions exists among singers and teachers concerning the precise signification of the term register. The human voice presents in the same individual certain sonorous qualities differing greatly according to the degree of the vocal scale in which it is examined. To these varieties, the names chest, falsetto,* and mixed voice are generally given.

Dr. Fournié's theory is by far the most philosophical; it is the one we shall adopt. He considers the three type voices, (chest, falsetto, and mixed), as the result of the vibration of the same sonorous body, the mucous fold covering the internal border of the chordae vocales, the difference between them being that in the production of each one, different lengths of the vocal membrane are set in vibration. This length is determined by the muscles of the parts.

The chest voice depends upon two conditions for its production:

* The terms *chest* and *falsetto* voice would seem to imply that the modifications of sounds to which those names are given are produced or resumed from the chest and *arriere-gorge* respectively. This is not so. The names indicate the character and quality of the sound alone.

1st. In the simultaneous increase in length and thickness of the vocal chords.

2d. In modifications in length of the vibratile parts of the vocal membrane. This length is determined by the length of the glottis, which is shortened from behind forwards in proportion as the tone rises.

These conditions characterize the chest register only when they exist simultaneously; that is, for any given note, the lengths of the vocal chords, their thickness, and the length of the vocal membrane must be constant in the same individual.

When the chest register is used, the transverse diameter of the glottis is small and linear, and the interior borders of the vocal chords which limit it are so thick and rigid that the air experiences a certain degree of difficulty in passing through the rima-glottis, and setting the vocal membrane vibrating; but it is precisely this difficulty which gives to the chest voice, the strength, roundness and energy which characterize it. We must remember that the intensity of the sounds depends upon the amount of force with which the sonorous body is set in motion.

The falsetto voice is found by:

1st. The shortenings of the glottis from behind forward, so that the vocal reed is much shorter than during the production of the chest voice. This shortening is produced by the contraction of the lateral crico-arytenoides. It is also shortened from before backward by the contraction of the oblique and vertical fibres of the thyro-arytenoidean muscles. The action of these muscles is direct, it being produced by their thickening during contraction.

The particular quality which distinguishes this register is dependent on the smallness of the reed which produces it, and is also due to the particular disposition of the different parts of the vocal pipe, of which we shall speak more at length when we treat of the timbre.

The mixed voice is produced by :

1st. A very long glottis, extending the whole distance between the thyroid and the superior border of the cricoid.

2d. A greater transverse diameter of the glottis than in the production of the other registers. This disposition of the parts results from the moderate tension exercised by the lateral crico-arytenoides and the thyro-arytenoides muscles.

The mixed voice is not produced by all singers in the same way ; almost every one has his own manner, the result of the lessons he has received and the formation and disposition of his vocal organs. Very frequently it is used to produce high notes by those whose organs are not sufficiently cultivated, and who thus remedy their insufficiency by a forced tension of the parts.

This register is a medium between the chest and falsetto, being softer than the former, but lacking the rich roundness which characterizes it. It is more sonorous, however, more far reaching than the falsetto.

Singing masters do not all agree upon the existence of this mixed register. Indeed many consider it as nothing more than a diminished chest voice. But in a physiological point of view the mixed voice exists. Less

painful to produce than the chest voice, it is also a period of rest for the singer. It is especially useful when the singer having arrived at quite a high note, experiences some difficulty in producing new ones. However, the singer should endeavor to develope as much as possible the chest and falsetto registers, and to obtain by a suitable variation of the timbre and intensity of the sounds of these registers all the various tones which the human voice is capable of producing.

Besides the chest, falsetto, and mixed voice we have also the so-called head voice, which is very often confounded with the falsetto. Let us see how it is formed.

In studying the anatomy of the vocal apparatus we found that the isthmus of the throat, or pharynx, was formed by a contractile surface lined with mucous membrane. The anterior portion of this is bounded below by the base of the tongue, and above by the veil of the palate and uvula; the two lateral walls being bounded by the pillars of the veil of the palate, and that in the recess or fossa between these pillars the tonsils were lodged; besides which the nasal cavities were shown to communicate with the pharynx and with several cavities or sinuses in the bones of the face. Now in the production of sound the veil of the palate or soft palate, as it is indiscriminately termed, plays a very important part, for being easily moveable, we can by means of it increase or decrease the size of the vocal pipe. This decrease takes place progressively from the lowest to the highest note. In fact, according to whether it rises or falls, the sonorous column of air is found to pass into the mouth or into the nasal fossæ.

During the emission of the head notes the soft palate comes in contact with the base of the tongue, and the sound resounds in the naso-pharyngeal region. Hence the name of head-voice.

If, on the contrary, the soft palate be raised so as to close the posterior part of the nasal fossæ, the column of air escapes entirely by the mouth.

CHAPTER VI.

TIMBRE.

We have seen that the intensity or volume of sound depends upon the multitude of the vibrations of the sonorous body, and is measured by the amplitude of the vibration of the auditory nerves; that the pitch depends upon the greater or less rapidity of these vibrations and the timbre or quality upon their form. Perhaps we had better say of the last that it is produced by the secondary sounds which alway accompany the principal one, and which, therefore, sets in motion accessory fibres of the ourisbular nerves.

A sound produced in the larynx traverses a vocal pipe of extreme mobility, and, therefore, it is not only possible, but almost certain, that the sound produced is greatly modified both in its volume and its timbre or quality.

The special timbre belonging to each individual depends upon the form, size, and particular state of the different parts of the vocal pipe. The smallest alteration in size, the slightest change in the condition of the parts, as that produced by an inflammation of the mucous membrane, by the enlargement of the tonsils, by the plugging up of the nasal fossæ, the loss of the

teeth, or an affection of the veil of the palate, is sufficient to change immediately its natural character.

The various shades of modification of which the voice in the same individual is capable, may be classed under the principal types; the *sombre timbre* and the *clear timbre.*

The *sombre timbre* results from the resounding of the voice in the vocal pipe, which is disposed in such a manner that the cavities are as large as possible and the orifices by which these cavities communicate with the external air, are sufficiently diminished in size to oppose any obstacle to the free exit of the air contained in the vocal pipe: to understand clearly the formation of this timbre, we have only while pronouncing aloud the letter A (French), to approximate the lips little by little, as if we wished to pronounce the letter O, always sounding the same note; we perceive that the timbre loses in a measure its ringing quality, in other words it becomes sombre. This modification of the timbre results evidently from the narrowing of the buccal orifice, which imprisons the sound in the mouth, and, consequently, favors its resounding in that cavity, and from the fact that to pronounce the letter O, the mass of air enclosed in the pharyngeal canal is required to escape less rapidly than while pronouncing the letter A.

The *sombre* is more musical than the clear timbre, and therefore produces a much more agreeable impression upon the ear, but it requires a well developed chest and a very solid larynx to sing much with it. It is well adapted to the Italian language, and is, in fact,

the one mostly in use among the singers of Southern Europe, since it is adapted especially to those languages where there is a preponderance of vowel sounds.

Dr. Fournié tells us that the French owe its introduction to Mr. Duprez, who with his sombre timbre had an immense success on his return from Italy. But its use in the English language would require a very considerable modification of the sounds of certain letters; for as we have seen, in order to give to the voice the peculiar qualities characterizing this timbre, the buccal orifice must be made smaller than in the ordinary voice and the jaws approximated, as in the pronunciation of the letter O, so that the *a* of *father* in singing would resemble very much the *o* of *other*, and the *a* in *fate*, would be like *e* in *her*.

The *clear timbre* is diametrically opposed to the preceding as regards its sonorous qualities and its formation; while in the sombre timbre the buccal orifice is slightly narrowed, in the clear timbre, the jaws are widely distended, and the mouth open. The same is true with regard to the isthmus of the throat, which, while it is narrowed in the sombre timbre, in order to enable the voice to resound in the pharynx, is, on the contrary, as large as possible in the clear timbre. The buccal and pharyngeal cavities undergo opposite modification in these timbres. In the sombre they are as large as possible; in the clear they are a little narrower than in the ordinary voice. The sounds produced are also diametrically opposite; for example, *o* is pronounced like *a* in *mat*, while the word *her* is sounded very much like *hare*.

There is besides the *sombre* and *clear timbres*, what Dr. Fournié has so well described as the *guttural timbre*.

The guttural timbre derives its quality from a too great narrowing of the isthmus of the throat, the *arrière gorge* of the French. This narrowing may be congenital, or may be produced by a swelling of the tonsils, or it may be the consequence of bad tuition. When the guttural or *throaty* timbre is congenital, it may be remedied to a certain degree by a daily exercise, consisting of the production of laryngeal sounds without the apparent assistance of the muscles of the throat. To do this, execute vocal exercises in front of a looking-glass, keeping the tongue projected as far as possible out of the mouth, and let also the opening into the throat be as large as possible. The mirror will guide sufficiently in the execution of this exercise; the pupil may also execute the vocal exercises upon the *e* of the word *met*, since the production of that sound necessitates the propulsion of the tongue forward and a relaxation of the throat, modifications indispensable to the end desired.

When the guttural timbre is owing to swollen tonsils, and this is generally the case, the sound is produced by the tonsils interfering with the contraction of the veil of the palate, and, consequently, it is prevented from discharging one of its most important functions, namely, the occlusion of the nasal fossæ. When this timbre is the result of neglect on the part of the teacher, it is perceived only during the emission of certain notes. It results often from the great exer-

tions singers make to reach very high notes. An exaggerated narrowing of the isthmus of the throat takes place during the production of those notes, and, no doubt, gives to them their guttural quality. But the voice loses in sonorousness the little it gains in range.

There is also a *buccal* and a *nasal* timbre, and to describe these accurately we had best follow the distinguished physiologist to whom we are already so much indebted.

In vocalization, that is, in the production of the non-articulated voice, we may cause the sound to pass through the nose or the mouth. In this way we may produce the pure buccal and nasal timbres. The latter is muffled, it is somewhat weak and possesses but little volume. These characteristics are, no doubt, produced by the small size and the flattened form of the cavity in which the voice resounds. The buccal timbre is distinguished from the preceding by the greater intensity, brilliancy, and volume of the sound.

Although it is possible to sing exclusively in either of these timbres, yet it is very rare that either one is exclusively used in vocalizing. Generally in the production of the grave and medium notes, the sonorous waves escape from both mouth and nostrils, while in the formation of the high notes the sounds escape exclusively from the mouth. The timbre then possesses a peculiar ringing quality and a slight degree of harshness indicative of its origin. Skillful singers, however, modify or conceal altogether this bad quality by a peculiar disposition of the mouth, consisting of an

increase in the size of the interior dimension, and a diminution of the buccal aperture. By these means they force the voice to resound within the buccal cavity and produce a timbre which softens that of the vocal reed.

Besides the timbres already given, there is a peculiar quality belonging to and distinguishing each individual which he cannot modify, and poetically called by the Germans the color of the sound. This is of the greatest importance in musical art, since it furnishes to it one of its most powerful means of expression. Anger, pity, joy, grief, love, each modify the voice, and in so characteristic a manner that even should the words escape us, the quality, the timbre of the sound alone would speak clearly. Fear and languor lower the voice; surprise takes it away, admiration prolongs it, hope makes it sonorous. There are strong voices, the sounds of which are loud and powerful; sweet voices, with flute-like tones, fine voices of which the timbre is always the same. There are voices exactly the reverse of these, hard, veiled voices, whose sounds are rough and without any ringing quality, uneven voices where the fine sounds are unequally distributed, and coarse voices where the fine, even timbre is altogether wanting.

"Until quite recently," says Dr. Fournié, "it was almost impossible to determine from the size, shape, and appearance of the larynx what kind of a voice the person possessed. Now, however, by the aid of the laryngoscope, the diagnosis is made easy."

The results of his personal observations have shown

him that the volume of the larynx is generally independent of stature; tall men sometimes having small larynges, while some small men have very large ones. The form and consistency of the vocal organs, however, coincide generally with the physical conformation and constitution of the individual. Indeed each person presents a conformation which is recognized almost as readily in a separate part as in the whole individual. It commonly happens that the man in whom the curved line predominates is corpulent, his bones but little developed, the cellular tissue abundant, and all the angles well-rounded. These characteristics or appendages of the lymphatic-sanguineous temperament, are also strikingly shown in the organs of the voice, and give to them an appearance and consistency greatly resembling those of the female larynx.

The prominence and depression produced by the thyroid cartilages in the front part of the neck are but slightly marked, the height of the larynx is comparatively small, the laryngeal cavity rounded, and the vocal cords, ordinarily very large, circumscribe a very small glottis. These anatomical peculiarities give rise to a voice which is very sweet and high-pitched, called the *Tenor*.

If, on the other hand, the straight line predominates in the individual, if the angles of the body be well marked, and the cellular-tissue small in amount, we shall find a well defined, salient angle, in the front of the neck (Adam's apple), a comparatively great height of the alæ of the thyroid-cartilages, and the laryngeal cavity greater in its antero-posterior diameter than the

former one, will have a correspondingly greater length of the vocal chords. These are the characteristics of the Bass voice. This voice is generally met with in athletic individuals, and the organs of the voice develop harmoniously with the remainder of the body.

The characteristics of the Barytone voice are midway between those belonging to the tenor and the Bass. If this voice be high pitched, the characteristics will be analogous in character to the tenor; if low, to the bass.

Voices are generally divided into the following classes:—

Female.	*Male.*
Soprano,	Tenor,
Mezzo-Soprano,	Barytone,
Contralto,	Bass.

This classification, based exclusively upon the pitch of the voice, answers well enough, perhaps, for the requirements of teaching, but seems as a scientific division incomplete, and based upon wholly insufficient grounds. In order that any classification of voice should rest upon sound principles, the divisions of voice should not only be determined by the pitch, but also by the timbre, the intensity and the volume, in short, by every thing which distinguishes one sound from another. It is evident that sounds are not sufficiently characterized by their high or low pitch; for we see baritone singers readily sing A and B, and tenor voices which sing A below. These notes, it is true, do not have the sonorous qualities which charac-

terized the other tones of these singers. The something, the *quid ignotum*, says Dr. Fournié, which distinguishes the A of the tenor from the A of the barytone, is due to the different timbre, intensity, and volume of the voice, in the tenor and barytone.

These conditions are necessary to a full appreciation of any sound, and we find a reason for their necessity in the study of the vocal apparatus.

If we take any note capable of being given by either a tenor or a barytone voice, the E in the fourth space, for example, we find that since it is about the middle of his natural register, it will be produced by the tenor without effort, will have a natural and agreeable timbre, and will be both as intense and voluminous as possible, since as the sound is moderately high, the glottis is open for nearly its entire length, and the resistance of the vocal membrane to the effort of the lungs is justly proportioned. The Barytone emits the note with a degree of difficulty; the timbre will not be like that of the tenor, since the vocal membrane is not as thin as in the tenor. The vocal membrane of the barytone is also longer, and to produce the same note a quarter degree of tension is requisite, and this tension also modifies the timbre, while the intensity and volume may be the same in both cases.

What has been said of the tenor and barytone applies also to the bass and the different female voices.

The soprano is the highest female voice, extending generally two octaves from C to C.

The mezzo-soprano of woman is analogous to the barytone of man. Like the latter it unites the two

extreme limits of the voice, and ranges generally from A to A.

The contralto is the gravest of female voices. Generally extending from F to G, the contralto may be recognized by the character of the larynx, that organ being more voluminous than usual in females. Its antero-posterior diameter is also larger than the average, thus rendering the thyroid angle or Adam's apple more prominent.

CHAPTER VII.

RESPIRATION.

PHYSIOLOGY teaches us that all animals live by the constant destruction and as constant renewal of their tissue, and that in order to remove the wasted products of destruction, certain excretory organs are provided. The lungs are perhaps the most important of these, for by the acts of inspiration the oxygen necessary for carrying on the change is introduced, and the products of combustion, water, carbonic acid gas, etc., amounting in all to about one half the waste of the system, are removed.

By the contraction and expansion of the chest, and the arching or flattening of the diaphragm, the motions of which the lungs follow, a portion of the altered contents of the pulmonary reservoirs is first expelled, and then a new supply of air introduced to undergo change in its turn, and as the lungs are never completely emptied, this change goes on constantly.

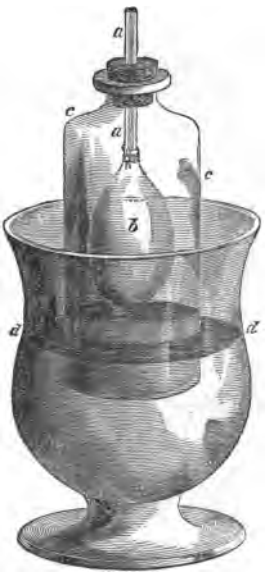
The movements of respiration are divided into two classes. 1st, those of inspiration, and 2d, those of expiration.

By *inspiration* is meant the act of introducing air into the lungs; this is accomplished by the movements

of the ribs from downward upward, from inward outward, and by the flattening of the diaphragm. It is divided into three stages. 1st, the mechanical, which consists in the introduction of air into the trachea and the larger bronchi; 2d, the diffusion of gases among each, by which air is introduced in the capillary bronchi and air-cells, and the foul gases pass outward; and 3d, the diffusion of gases through membranes, by which the oxygen reaches the blood, and carbonic acid gas and water are given off.

An experimental illustration of the manner in which the air is introduced into the cavity of the lungs by the descent of the floor of the chest, and then expelled by its elevation, is represented in Fig. 8, in which *a a* is a tube of glass half an inch or more in diameter, and six or eight inches long, to the lower end of which a bladder, *b*, is tightly attached. The tube is passed through the neck of a bell-jar, *c c*, air-tight. A large glass reservoir of water, filled to the height *d d*, receives the bell-jar, as shown in the figure. When the jar is depressed in the water the air is expelled from the bladder, and when the jar is raised the air flows in. By alternately elevating and depressing the bell, the bladder exe-

Fig. 8.



MECHANISM OF THE RESPIRATORY APPARATUS.—(DRAPER.)

cutes movements like those of the lungs, of which, indeed, it is a representation; the glass tube being the trachea, the bell-jar the walls of the chest, and the rising and falling water-level the rising and falling diaphragm. In this illustration the bladder is, of course, perfectly passive, as was at one time supposed to be the case with the lungs.

By *expiration* is meant the act of expelling the altered air from the lungs and air-passages, and is the exact reverse of inspiration. The stages are—1st, diffusion through membranes; 2d, diffusion of gases amongst each other; 3d, mechanical. It is produced by the lowering of the ribs and the rising of the diaphragm.

In ordinary tranquil respiration, the contraction and dilation of the chest is effected almost entirely by the diaphragm, aided by the elasticity of the muscles of the abdomen, the movements of the ribs being almost imperceptible; but in the breathing necessary to singing or speaking, the walls of the thoracic cavity take an active part. Formed chiefly by the ribs which are arched symmetrically between the vertebral column, or back bone, and the sternum, or breast-bone, and moveable on account of their cartilaginous union with those bones, they act on the lungs, by their elevation or depression, in the same manner as the sides of a bellows, and by their simultaneous movements produce a dilation or contraction of the thoracic cavity, and so fill or empty the lungs. On account of the manner in which the intercostal muscles are attached, the movements of the ribs increase rapidly from the first to the

last, so that the eleventh and twelfth enjoy from ten to eleven times the mobility of the second.

The respiratory movements are partly voluntary, partly involuntary. Partly voluntary in order that they may be subservient to the purposes of singing, speaking, or the necessities of such labor as produces a rapid destruction of the tissues of the system, and demands as rapid a removal; partly involuntary, lest in sleep, or in a moment of forgetfulness, the movements of respiration should be suspended, and fatal consequences ensue.

The capacity of the chest varies greatly in different individuals, and bears a constant relation to the height of the individual. But the size of the chest is no criterion as to the capacity for inspiration or expiration, which is the only accurate method of determining the development of the lungs. On an average, some 16 or 17 inspiratory movements occur in a minute, and in an adult of average size, we may assume, according to the experiments of Mr. Coathupe, that about 266⅔ cubic feet or 460,224 cubic inches of air pass through the lungs in 24 hours. Reckoning the average number of expirations at 16 per minute, this would give about 20 cubic inches of air expired at each. The experiments of Dr. John C. Draper, which were conducted with great care, and from which the error of time was eliminated, each experiment being carried on for 20 minutes, give 16 as the number of inspirations per minute, and 38.8 cubic inches of air as the average inspiration;—the least amount sufficing for the wants of the system, 511 cubic inches, the greatest capacity

of lungs, 1077 cubic inches; and that the amount of air introduced depends for the most part on the rapidity of respiration.

"Besides the movements of expansion and contraction described above, belonging to the chest, there are similar respiratory movements taking place in the larynx. While respiration is going on there is a constant and regular movement of the vocal chords, synchronous with the inspiratory and expiratory movements of the chest, by which the size of the glottis is alternately enlarged and diminished. At every inspiration the glottis opens and allows the air to pass freely into the trachea; at every expiration it collapses and the air is driven out through it from below. These movements are called the 'respiratory movements of the glottis.' They correspond in every respect with those of the chest, and are excited or retarded by similar causes." (Dalton, p. 240.)

During inspiration the tongue and os hyoid are thrown backward, the epiglottis straightens from behind forward, the larynx descends, the lips of the glottis are carried outward by the separation of the arytenoid cartilage, and the trachea is shortened and widened. During expiration the reverse of all these movements takes place; the tongue and hyoid bone being carried forward, the larynx ascending and narrowing, the lips of the glottis approximating, and the trachea narrowing and lengthening.

The peculiar art of singers especially, and of speakers, consists in a great measure in the proper management of the respiratory apparatus. If we

abandon ourselves to instinct, we all respire equally well.

Respiration is not then a thing to be learned, but when the will intervenes, as in singing or speech, it may happen that one of those means may be exaggerated to the prejudice of another; in such a case we should strive to return to the normal type of breathing, or at least to use that type which is best suited to produce the desired effect. The names of costal, diaphragmatic, and ventral respiration, are just so many distinctions which puzzle both singer and speaker; the truth being that to respire well and naturally, the ribs, diaphragm, and abdominal muscles must each do their appropriate work, and as Dr. Fournié justly observes, "he who respires exclusively by one or the other of these alone, must be a sick man."

Many of the faults of the singer or speaker are imputed to weakness of the voice, when, in fact, they are caused by a bad method of breathing—the singer either not taking breath at the right time, or not often enough, or not long enough. Some contract the muscles of the body as powerfully as they can, and thus disturb the action of the respiratory muscles. Is it at all surprising, when the singer attempts to move so many muscles at the same time, that one set should act but imperfectly? This person cannot recite or sing for even a few moments without his mouth and throat becoming dry and irritated; it is, possibly, because he does not breathe methodically. That one desires to utter a voluminous sound, and fails miserably, because he has not filled his lungs

sufficiently. Another, in order to breathe, presses with all his force upon the floor, contracts, as far as he is able, the muscles of his extremities, and thus attempts to impart energy to his voice; the result, commonly, is the opposite of the one sought. Let the singer or speaker breathe naturally, and abstain from all the unnecessary and injurious efforts which only disturb those parts which carry on respiration.

In singing, especially, a skillful use of the respiratory apparatus is demanded; it does not consist in the use of any one particular method of breathing, but the singer should study,—1st, to develope a natural respiration—2d, to learn above all to respire in a manner best suited to produce the desired effect—and 3d, to fill the lungs as completely as possible at each inspiration; for if the lungs be but partially filled each time, it will necessitate a frequent repetition of the respiratory movements, which will interrupt the singing in a very disagreeable manner, and render it any thing but pleasant.

When after an ordinary expiration the ribs have been lowered and the diaphragm has returned to its normal situation, there yet remains a little air in the lungs which allows of a still further prolongation of the expiration. To produce this prolonged expiration the abdominal muscles are called into action. They effect it by compressing the anterior and lateral walls of the abdominal cavity, diminishing its diameter, and so pushing up the organs contained in it toward the thoracic cavity, forcing up the diaphragm, and thus expel-

ling almost completely the air contained in the lungs. It is to this method of respiration that the name of ventral has been given.

The voice may be greatly modified and improved by the natural or acquired possession of a prolonged inspiration and a methodic expiration. This consists in a deep inspiration, which will fill the lungs to their greatest capacity, united to the precaution of not aspirating when breathing.

In the execution of a piece of music, the inspirations, always deep, must be slow or fast, according to the character of the music and the manner in which its phrases are divided. Thus during the rest or the half rest, the inspiration may be slow, while in a musical phrase divided by semi-quaver or demi-semi-quaver rests, it must take place rapidly. In all cases, however, it is necessary to be guided in the depth of the inspiration by the length of the musical phrase to be emitted, in order to have a sufficient quantity of air to produce perfectly each note, and to avoid exhausting the lungs completely of air before the musical phrase be ended, or a rest of some kind is reached that will allow of a new inspiration. It is even necessary that a certain amount of air be always held in reserve in the lungs after the execution of each period; in this way the final note will always be given with greater precision, and the voice will be much more sonorous. It is by the application of these principles that great artists give to the voice an extraordinary range, and succeed in renewing the air in the lungs at certain

points of very long passages. Habit and taste will alone enable one to determine the precise moment, when without injury to the musical effect, and sometimes without even its being perceived, that inspiration may be effected.

CHAPTER VIII.

ALIMENTATION.

To live, it is necessary not only to have received life, but to maintain it. The condition upon which nature has given man life is, that he shall repair the waste of its force, by means of the materials which she gives him for that purpose, and which he converts into his own substance. It is not enough to live, but to fulfil our part we must live long, and enjoy good health; to do this, we must have a sufficiency of well-chosen aliments—in other words, man lives only by a constant destruction and as constant a reparation of his tissues. We have seen that fully one half this waste or burning of the body is accomplished by the air introduced into the lungs, consequently the greater the amount of air respired the greater the waste. No one can sing much or read much without a great increase in the waste, which can only be repaired by food, to form new tissue. Thus we see that the stomach is almost as essential to singing and reading as the larynx or lungs.

"There is amongst singers," says Mr. Segoud, "a prejudice concerning alimentation. A great many of them expect to find in a frugal diet a sure guarantee

against the alterations of the voice, but when the singer perceives that in breathing he burns his own substance, and that the reparation is made by alimentation only, he will understand that breathing much more than the man who does not sing, he must repair his enormous losses by a diet of the most nutritious character. Then and "then only" living in a perfect equilibrium he will preserve his voice in its strength and compass, and no longer be exposed to the numerous and severe disorders of the vocal apparatus which develope themselves so quickly in an exhausted organism.

We have seen that an adult in good health makes on an average 17 inspirations in a minute and inhales from 17 to 20 cubic inches of air in each inspiration, that is from 10 to 12 cubic feet per hour or from 240 to 280 cubic feet in 24 hours. Yet these amounts enormous as they seem are far less than those required for the respiration of the singer. Unable to deliver long musical phrases without respiring deeply, he accustoms his lungs to contain the greatest possible quantity of air.

Dr. J. C. Draper's experiments upon respiration are of importance in this connection. He found that the average number of respirations per minute was 16 and 622 cubic inches were exhaled per minute or an average of 38.8 cubic inches in each respiratory act. He also sought to determine the least amount necessary to satisfy the wants of the system for a considerable period and also the greatest amount exhaled when respiration was hurried and each act was as full as pos-

sible under the circumstances. His result may be thus tabulated.

No. of Respirations per minute.		*No. of Cubic Inches per minute.*
6	Least amount sufficing for the wants of the system, . . .	511
16	Average demand, . . .	622
33	Utmost extent of respiratory system,	1077

From which he concludes:

1st. Amount of air in each normalr espiration is 38.8 cubic inches, the number of respiratory acts being 16 per minute.

2nd. The amount of air introduced into the system depends for the most part upon the rapidity with which respiration is carried on.

From this we conclude that the ordinary quantity expired by the singer when vocalizing—even if he makes but 10 respirations per minute—cannot be less than 800 cubic inches per minute. Here we have 3 times the amount of air respired normally, and hence in no other physiological state have we the respiration so much exaggerated as in singing.

How is the singer to make up the great waste which his body undergoes? By alimentation only.

Among the innumerable articles of food capable of satisfying the wants, and even the sensuality of man, some, born directly of the earth, or produced by animals, can be consumed immediately—fruits, milk, are examples of this class. Others, before being employed, require to be submitted to the action of fire,

and to more or less varied culinary preparation. This class includes the flesh of animals, and the great majority of vegetables. The first may be beneficial or hurtful, either by their intrinsic properties or by some property acquired, or may be due to insufficiency or want of development of the fruit. The second class may also be of use to, or have a bad effect upon, the human economy, for the same reason as the first—their own nature, natural modifications, or modifications which man causes in them. A plum, however good it may be, is less salutary than a pear; green grapes are injurious, while ripe grapes possess contrary properties; mutton is, as a rule, more easily digested than pork; the flesh of an over-worked ox, less digestible than that of a steer which has been prepared for the market; or, generally, an aliment properly prepared and cooked, is more beneficial than one in which the necessary culinary operations have been neglected.

That the good or evil effect of any substance used as food does not depend altogether upon the intrinsic properties of the aliment, or upon the changes impressed upon it by the hands of man, will be evident upon a slight examination. Its effects upon the system are dependent, in a great measure, upon the modifications it undergoes in the digestive tract, and it is in the inability of the digestive organs to impress the modifications upon the aliments, that we are to find one of the most prolific sources of gastric disease. The first of these causes would depend upon the condition of the digestive organs themselves—whether healthy or

diseased, at the moment the aliments are placed in contact with them; the second class of causes are dependent upon the state of the food itself, at the same moment. If the aliments, either through deficiency of teeth, or inability in the lower jaw to execute the movements necessary to mastication, or from the habit of hurrying through the meal, are improperly masticated; or if, from disease, the salivary glands cannot pour out the juices which nature designed to be mingled with the food before its introduction into the stomach, it is evident that there will be more or less difficulty of digestion, though the food be perfectly suitable, and well prepared. This state of affairs will be evidenced by a feeling of fulness and nausea, or by eructations.

The condition of the stomach at the time of ingestion must also be taken into consideration. It may not be well disposed to the reception of food, on account of some gastric trouble, or of a threatened inflammation; of impairment of nervous power, brought on by too long continued mental strain, or by some moral influence, pleasant or otherwise. The aliments themselves, in such conditions, also exert a great influence, according to the portion of the digestive tract in which they are chiefly acted upon—one being digested easily, while another, if not at once rejected, produces severe digestive disturbance. Thus, black meats are digested almost entirely in the stomach; while vegetables, or fatty substances, are acted upon in the intestines. It is well, therefore, in such cases as those mentioned, to adapt the food to the condition of the organs, and to advise those aliments which would enable diseased

parts to remain as quiescent as possible, and thus afford them a chance to recover their strength.

The constitution, sex, age, the general condition of the health, and the occupation, have a great influence in determining what kind of aliments shall be chosen, and what effects will be produced upon the system. Thus, a man of vigorous constitution, with a well-developed muscular system, and whose avocation demands a moderate amount of physical exertion, may indulge with impunity in a thousand excesses of diet, the least of which might be sufficient to hurry to the grave his neighbor, a pale, weak, melancholy young man. This difference in the quality of food, because of disparity of physical development, accounts in a great measure for the difference exhibited by men and women in the choice of their aliments, and why women in a state of pregnancy, or persons exhausted by chronic disease, possess such infinitely fanciful appetites. It is for the same reason that some are rendered quite ill by a slice of melon, or a chop of pork, which would be readily digested by the stomach of another.

Two other prominent causes which influence both our choice of alimentary substances, and the greater or less facility with which they become identified with the substance proper of the body, are climate and season. See the difference in the diet of an Esquimaux and that of an inhabitant of the tropics—the one devouring fats, oils, etc., with avidity, while the other lives almost exclusively upon fruits and farinaceous substances. We may come even nearer home—take ourselves as an example of the effect of season. With what a rel-

ish, during the winter, do we sit down to a substantial meal! The stomach receives, with avidity, animal food, fat, and other dishes of a like substantial nature; but when the heat of summer comes, do we not all know that the appetite languishes, and that dishes which, in the cold season, were eagerly waited for, possess now no relish? We eat slowly, and but little; and instead of meats, seek eagerly cooling and refreshing fruits and vegetables.

The hour at which we enjoy the pleasures of the table exerts a far greater influence than is ordinarily supposed upon the process of digestion. The ancients, who understood thoroughly the science of gastronomy, were in the habit of consecrating the end of the day to the reparation of the corporeal forces, and the joyous effusions inspired by the repast. It seems, indeed, as if, at that hour of silence and peace, there is spread over the whole nature a happy calm, which ought not to disturb in any way the important mystery of the daily resurrection, which we are about to entrust to its benignant influence. At that hour, the air is refreshed by the absence of the sun, and the rising of a temperate breeze; the forces of the economy, employed during the day in the secretion of an abundant perspiration, experienced a beneficial diversion in being directed to the performance of the digestive functions; professional labor had ceased, and man, enchanted at being enabled to rest from his cares, found in the satisfaction of an imperious need, new sources of illusion and peace.

We, living under a sky not so pure, a climate less mild, and fettered by a different social system, and a

much more complicated civilization, are not enabled to choose that hour for our principal meal, and should favor as much as is in our power, an early dinner. Fashion has decided, and who shall gainsay her, that all places of amusement shall be opened in the evening; that we shall visit or receive our friends in the evening. The consequence is, if we dine late, that, in order that we may be ready, we must hurry through our meal; the food is driven to the stomach with such frightful rapidity that it scarce scrapes acquaintance with the teeth or salivary juices, and imperfect digestion follows, as a necessary consequent. *What matter? We enjoy ourselves, but we forget to live.*—BROUC.

Modern chemists divide all substances fit for food into two classes.

1st. The nitrogenized or nutritious substances, also called Histogenetic, since they are employed in nourishing all the tissues of the body to a greater or less degree: they are,

Albumen (white of egg is the purest form; also in blood).

Fibrin (flesh and blood of animals).

Gluten (or vegetable fibrin, obtained from any plant or from washing flour, till the water is no longer whitened).

Casein (the curd of milk, material forming cheese.)

2nd. The non-nitrogenized or respiratory substances.

They are subdivided into two classes.

1st. The hydro-carbons, such as butter, fat, and all oily bodies containing an enormous amount of carbon and hydrogen and but little oxygen.

2nd. The carbo-hydrates (so called from the hydrogen and oxygen existing in the proportions to form water) such as: sugar, starch, gum, and similar substances.

To these we may add beer, wine, etc.

These are the substances to which the singer must principally resort for the reparation of the loss he has sustained from his forced respiration.

It would be well also for the singer or speaker to abstain from using the voice for a few hours after eating, since when the stomach is distended by food the increased size of that organ prevents in a measure the lowering of the diaphragm, and, therefore, the respiratory functions are not carried on as well, the least effort becomes painful and fatiguing, and the voice itself is heavy.

The singer will then avoid practising during digestion for three reasons:

1st. He would sing out of tune.

2d. He, by continued practice, would probably become dyspeptic.

3d. He might produce grave disorders of the circulation.

It is difficult to determine exactly the interval which should intervene between the end of a meal and the beginning of vocal exercise, it varies according to the power of digestion of the individual, and especially according to the quantity and kind of aliments taken.

As a general rule, it will be prudent and in accordance with hygienic laws not to sing for at least two hours after the principal meals.

According to Dr. Beaumont, the average time re-

quired for digestion varies from 1 to 5½ hours, depending upon the kind of food employed.

The following table giving the time necessary for the digestion of various articles of food, shows that the method of cooking also influences the rate of digestion.

Table showing the Time required for the Digestion of various Articles.

	H.	M.		H.	M.
Apples, sweet, raw	1	30	Milk, boiled	2	00
" sour, mellow, raw	2	00	" raw	2	15
Beans, pod, boiled	2	30	Mutton, fresh, roast	3	15
Beef, fresh, rare, roasted	3	00	" " broiled	3	00
" " dry, "	3	00	" " boiled	3	00
" " fried,	4	00	Oysters, fresh, raw	2	25
Beets, boiled	3	45	" " roast	3	15
Bread, wheat, fresh baked	3	30	" " stew	3	30
" corn, " "	3	15	Parsnips, boiled	2	30
Butter, melted	3	00	Pork, fat and lean, roast	5	15
Cabbage, with vinegar, raw	2	00	" " broiled	3	15
" boiled,	4	30	" " raw	3	00
Catfish, fried	3	30	Potatoes, Irish, boiled	3	30
Cheese, old, strong, raw	3	30	" " baked	2	30
Codfish, cured dry, boiled	2	00	Rice, boiled	1	00
Corn, green, and beans, boiled	3	45	Sago, "	1	45
Custard, baked	2	45	Salmon, salted, boiled	4	00
Ducks, domestic, roasted	4	00	Soup, beef, vegetable	4	00
" wild, roasted	4	30	" chicken, boiled	3	00
Eggs, fresh, hard boiled	3	30	" oyster, boiled	3	30
" " soft "	3	00	Tapioca, boiled	2	00
" " fried	3	30	Tripe, soused, boiled	1	00
Flounder, fresh, fried	3	30	Trout, salmon, fresh, boiled or fried	1	30
Fowl, boiled	4	00	Turkey, domestic, roast	2	30
" roast	4	00	" wild, roast	2	18
" fricasseed	2	45	Turnips, boiled	3	30
Goose, roast	2	00	Veal, fresh, broiled	4	00
Lamb, fresh, boiled	2	20	" " fried	4	30
Liver, beef, boiled	2	00	Venison steak, broiled	1	35

Hence the singer should distribute his hours of practice according to his meals, or reciprocally if he is obliged to sing at given hours.

Although there would generally be no harm done by eating immediately after singing, since the aliments taken tend to repair the waste of the system, yet it is better to allow the body to rest for a short time, until the artificial congestion of the vocal apparatus brought on by singing shall have passed away entirely, since the heat of the food and the excitant articles, such as pepper, mustard, etc., used with it might become in this congested condition so many causes of inflammation of the tissues of the pharynx.

Thus we see that to sing well, the digestive must be in harmony with both the respiratory and the vocal organs; therefore, the singer should take particular care that the stomach performs its functions well, for as long as he digests well, he can sing with impunity, but, if the stomach fails to do its duty, and he still persists in tasking his lungs, he burns his own substance without having any means of repairing the waste, and this, if continued in, will lead him to an early grave.

CHAPTER IX.

HYGIENE OF THE VOICE.

THE charm which irresistibly accompanies singing, attests the great advantages and happiness which those who cultivate it may derive from it. The seducing power of a fine voice, whether a gift of nature or the happy effect of well-applied art, captivates, notwithstanding the origin, age, and social relation of the possessor. Apart from its salutary influence upon the mind, singing serves eminently to develope and strengthen the vocal and respiratory organs, while the animal economy experiences the beneficial results to be obtained from an exercise full of charm and beauty.

During the action of singing the lungs require a rapid development and are rendered less liable to disease. Hence the researches of physiologists have established the fact that exercising the voice is a great preventative to the development of pulmonary consumption.

But, although moderate exercise in singing may be beneficial on account of the increased action of the pulmonary system, yet its excess is very injurious.

The act of singing, if long continued, ordinarily produces an artificial congestion of the bronchial tubes,

the larynx, the pharynx, and the isthmus of the throat. The parts thus congested, if exposed to a low temperature, inflame readily, and a great number of the sore throats and bronchial troubles met with are developed under these conditions. The precept of never exposing ourselves to cold or damp air immediately after any exercise in which the vocal organs have been violently exercised is of great importance. The world, known hoarseness of singers is a proverbial thing, and if sometimes it is an excuse, too often it is a reality. During the prevalence of cold weather, it is only necessary to sing for a few minutes, and then expose ourselves immediately to the cold air to contract that hoarseness. These remarks do not apply to the singer alone; the attorney after his pleading, the professor after his lecture, the preacher after his sermon, in short all persons who for a certain time have to speak warmly and earnestly, will have to take the same precautions, in order to avoid the trouble we have mentioned.

Lyric or dramatic artists who are compelled on account of their profession, to remain during a greater or less period of time with portions of the body uncovered, may by certain precautions diminish in a great measure the injurious effects of cold. Thus, instead of remaining near a good fire until the moment before appearing on the stage, they should just warm themselves and then try to keep up that artificial warmth by some moderate exercise, such as walking up and down the room. They should also accustom those parts of the body that are to be uncovered, to bear exposure to the cold by wearing but a moderate amount

of clothing, so that they will be less sensitive when exposed. It is true, there often exists in artists a physiological condition which enables them during the time they are actively engaged in their professional labors, to brave, with greater or less impunity, this exposure. This condition is dependent chiefly upon the state of their nervous and circulatory systems at the time; excited by their theme, sustained by the sympathies of the public, and animated by a desire to satisfy them, they are no longer ordinary mortals, to be overpowered by every exterior agent. In vain, draughts of cold air play upon naked shoulders, or lightly-clad bodies; the great excitement under which the system is laboring is far stronger than the foe which seeks to overwhelm it; the great amount of heat developed in the body effectually prevents the action of the exterior cold; the brain is so occupied with the scenes which the artist represents, that all influences which ordinarily would produce an impression upon the periphery of the body, are now powerless. This condition of excitement generally lasts for some time after the cause which has produced it has disappeared. But in the same degree as the artist was before unimpressionable, so, after this excitement has passed away, do external causes affect him. A reaction takes place in the organism, which, unless the artist be very vigilant, and protect himself well against the influence of the surrounding atmosphere, may have a pernicious influence upon him.

Loud and animated conversations are also injurious. Many of our great artists, when they are about to sing,

abstain entirely from conversation, and remain for hours together in the most absolute silence.

Whispering is still more injurious than speech. In this country where almost every one who sings belongs to a church choir, we cannot condemn too strongly the practice of whispering between the selections. Were the singers to remain perfectly silent, there would be not only a great deal less of the disagreeable hemming so common at the beginning of each piece, but much better singing.

Immoderate or loud laughter also should be avoided, for the practice, if continued, will in a short time produce a great weariness of the larynx, and dryness of the throat. There is also during this act a spasmodic tension of the vocal chords, which, when the laughter is prolonged, brings on a very painful feeling of strangulation.

When we studied the structure and movements of the vocal organs, we found that during respiration the greatest movement takes place at the base of the chest, and since the thoracic walls must act with ease and rapidity in order to sing or speak well, this portion of the chest must have perfect liberty of motion. Beware, ladies, lest in your sacrifices to the goddess of fashion, you make your waist so small that you diminish the range and power of your voice, and thus sacrifice one of the most precious advantages to one of the most foolish and frivolous. If a tightly-laced waist, in the ordinary routine of daily life, when no great exertion of the lungs is called for, is both dangerous and inconvenient, since it interferes with

the pulmonary and abdominal circulation, how much more so must it be when the wearer attempts to recite or sing.

It is evident that every time an effort is made to inspire suddenly or deeply, or in singing to expel economically the air contained in the lungs, there will be found in too tight a corset or dress a great obstacle to the accomplishment of these two movements.

In the deep and sudden inspiration the corset will necessarily resist, and the singer will not be able to introduce into her lungs the necessary amount of air: on the contrary, in the expiratory effort when she desires to expel skillfully and economically the air contained in the lungs, the corset will hasten the expiration, forcing the singer to breathe often, and preventing her from making use of the whole extent of her voice. Again the pressure produced on the abdomen prevents the movement of the organs contained in that cavity, and hence the respiration carried on by the movements of the diaphragm is to a great extent interfered with. In this we find an explanation of the greater movement of the upper portion of the chest in women than in men.

Dr. Goddard in his "Essay on Tight-Lacing," says:

"1st. Corsets should be made of smooth, soft, elastic material; 2d, they should be accurately fitted and modified to suit the peculiarities of figure of each wearer; 3d, no other stiffening should be used but that of quilting or padding; the bones, steel, etc., should be left to the deformed or diseased, for whom they were originally intended; 4th, corsets should

never be drawn so tight as to impede regular, natural breathing, as, under all circumstances, the improvement of figure is insufficient to compensate for the air of awkward restraint caused by such lacing; 5th, they should never be worn either loosely or tightly during the hours appropriated to sleep, as, by impeding respiration and accumulating the heat of the system improperly, they invariably injure; 6th, the corsets for young persons should be of the simplest character, and worn in the lightest and easiest manner, allowing the lungs full play, and giving the form its full opportunity for expansion."

The same remarks concerning tightly fitting clothing apply equally well to men. They should not wear either tight shirt collars or cravats, for the voice is seriously interfered with by compressing the larynx, and even rupture of the cephalic or thoracic vessels, resulting in sudden death, may be the penalty paid by the imprudent singer or speaker, who fearing to disarrange his toilet, has neglected to take a precaution which is always useful and often indispensable, especially to plethoric individuals. Therefore do not forget to have the neck perfectly free, for besides the danger and the uneasiness produced in that region, it causes a preoccupation of the mind always injurious to both sentiment and execution.

We would also advise those who devote themselves to singing, to conform less to the tyrannical power of certain fashions. No matter what the season is, women expose to the action of cold or damp air, their bare necks and arms, or even may be seen shivering in gar-

ments so slight that they scarcely suffice for the demands of modesty. Thus dressed and often wet with perspiration they pass suddenly from a warm apartment to an icy atmosphere, and by so doing expose themselves to fall a victim to one of the many and troublesome diseases to which a sudden cooling of the surface of the body may give rise, such as Phthisis, Bronchitis, Digestive disorders, etc. Fortunate indeed are they if they pay the penalty of their imprudence with a cold or loss of voice, but too often death or a life rendered miserable by pain and sickness follows this neglect. Who is there who has not been compelled to watch some young friend descend slowly to the grave, with the emaciated body, the frightful spasms which every evening threaten suffocation, the hectic fever, the copious night sweats, and putrid expectoration, the too sure signs of that fell destroyer, consumption?

The singer, on account of the susceptibility of his lungs to the influence of cold which the frequent use of his voice developes, must not spare any means of preserving those organs from the abrupt variations of temperature. He can in a great measure protect himself by the use of flannel, which not only keeps his body warm, but renders the lungs and bronchial tubes less sensitive to cold by keeping up a slight irritation of the skin.

Experiments conducted with a view to determine the effect on the body of different materials of which the ordinary articles of clothing are made up, have shown that those made of wool are the warmest. They not only retain the heat of the body, but the perspiration

which is constantly poured out by the body immediately passes through the texture of the fabric, and thus enables the skin to fulfil its function perfectly. An individual, young, and in the enjoyment of vigorous health, may dispense with the use of flannels without subjecting himself to danger or even inconvenience from the frequent changes of temperature of our climate, provided he takes moderate care of himself. But later in life, and even in youth, if the constitution be not good, or if from a feeble state of health but little heat is developed, or if sedentary occupations are followed, woolen undergarments become almost absolute necessities.

Nothing produces catarrhal affections of the vocal organs more readily than cold. The effect is the same whether the cause be the inspiration of cold air, the swallowing of ice-cold drinks, or a current of cold air upon the surface of the body. The practice of rubbing the skin from time to time with flannel or a flesh brush, stimulates the cutaneous surface and opposes more or less the tendency which certain constitutions have to catarrh.

During the interval or rather previous to singing, what does the singer do? His main object is to effect the complete lubrication of the buccal and pharyngeal mucous surfaces. This he accomplishes by means of the salivary secretion, a part of which he distributes with his tongue over portions of those membranes, while he swallows the remainder to aid the follicular secretions in moistening the throat.

A great many people strive to attain the same result by the use of lozenges or troches. Especially is

this seen in the green-room, the choir, the hall of justice and the pulpit. Fortunate indeed is it for those who indulge in these so-called medications, that the greater number of them are perfectly inert. A few however are powerfully narcotic and soon become very enticing, nay, almost indispensable. Others again are so powerfully astringent that they rather increase than diminish the inflammation which they are intended to allay, and are but too often the originators of dyspepsia.

I speak knowingly of these things, since I have tried them all. As a singer, I found the best worse than useless; as a medical man, I find most of them positively injurious.

The troches most in vogue contain cubebs as a base. While cubebs, in its therapeutic effects, promotes the secretion of mucous surfaces, it presents great disadvantages in destroying the tone of the mucous membrane of the stomach, thus interfering with gastric digestion, and thereby inducing dyspeptic symptoms, such as acidity of the stomach, loss of appetite, water-brash, etc. Where the singer or speaker is concerned, we have in view, to facilitate expectoration, and allay inflammation, relieve hoarseness and soothe bronchial irritation, the natural results of too prolonged exertion of the vocal organs.

To accomplish these results, I have for several years been accustomed to use and often have prescribed, for artists and clergymen, and with very good results, a preparation of Pimpinella Saxifraga, Pulmonaria, Erysimum, and Bromide of Ammonium, held in Gum Acacia.

This has lately been made into lozenges by a chemist of this city.*

There is a point of considerable importance, the consideration of which is very often neglected; that is, that the size of the room be limited and that it sustain a harmonic relation to the energy of the pulmonary and vocal organs. If the room be so large that the singer or speaker is compelled to exert himself greatly in order to fill it, the sounds will lose their natural tone; his lungs, strained by being so forcibly dilated, will tire; his larynx and bronchi become irritated or even inflamed; and his tongue and throat, no longer sufficiently lubricated by saliva, become rigid. Happy indeed is he who early perceives the ill effects he is producing, and by a timely avoidance of the cause protects himself from consequences still more dangerous.

Emotion may act upon the organism in such a manner as to render the singer or speaker unable to produce the slightest sound; or he may be unable to produce distinctly the one desired, or the sound may be diminished in intensity or pitch; or, by its action upon the salivary glands, the mouth, tongue, larynx, etc., become dry, and the voice loses both in sonorousness and range.

It would be strange if artists who are constantly exposed to the influence of emotion did not endeavor, by some means or other, to overcome that influence. Each one has some remedy for his or her trouble; one eats a hearty meal, another drinks coffee, another liquor, another takes opium, and each believes that without

* Wenck's Laryngeal Lozenges.

his stimulant he would be unable to overcome the effects of the influence of emotion. An eloquent divine of this city is said to take some eight to ten cups of tea before going to his Sunday services.

In the chapter on alimentation we showed the evil effect of a full stomach upon the voice. Let us now consider the effect of the other substances, and see whether there is any necessity for their use in order to counteract the effects of emotion.

Coffee has been the subject of the most lavish praise and the most unjust blame. Certain it is, that, if it does not accomplish all the good claimed for it, it at least does not produce all the evil effects which are so complacently attributed to it. One of its evil effects, however, we cannot overlook, namely, its deadening the sensation of hunger. There are but very few great coffee drinkers who are great eaters. If a person, not a habitual drinker of coffee, take some before a meal, he will be unable to eat the average amount of food which he is accustomed to do; while, if he takes it after a meal, a much longer interval than usual will elapse before he is again hungry. Again, the energy of the berry is in a measure destroyed by the quantities of milk ordinarily employed, and for this reason it often happens that the only effect of coffee is to slightly stimulate the digestive organs.

The power of coffee to excite the cerebral functions has been very much extolled. That it does so, there can be no doubt; but we pity the man whom habit has compelled to resort to this stimulant. We can readily understand why a person advanced in years

may resort to it, but think that any one who is still young and of vigorous constitution, would do well to abstain from the habitual use of coffee as a stimulant, for it increases the force of the circulation, diminishes the appetite, and finally becomes an imperious want, the privation of which produces indigestions and almost intolerable headaches.

Coffee does not affect all individuals uniformly. On some its influence is soothing, while others are rendered so nervous and excitable by it, that they dare not continue its use. It is evident, then, that individual peculiarities must be consulted before its use is decided upon.

But of all stimulants the ones which affect man most are liquors, the product of alcoholic fermentations, since they may be infinitely useful or terribly injurious, accordingly as their use is reasonable or abusive. Their action in great measure depends upon the amount of alcohol contained in them, the quantity and kind of gas, and the amount of sugar, extractive or coloring matter, etc., which enter into their composition.

Their influence upon the liver is fatal; they increase the amount of the biliary secretion, and tend to produce dangerous coagulations. They also generally increase the secretion of the gastric fluids, and facilitate the coagulation of the mucosities existing in the stomach. But it is principally upon the nervous system that their influence is most manifest. Taken immoderately their tendency is to pervert the salivary secretions, to destroy the sensitiveness and suppleness of the mucous membrane lining the respiratory organs, and thus give a

feebleness and often a disagreeable hoarseness to the voice.

The best way to overcome the influence of sudden emotions, is to cultivate the habit of breathing easily, tranquilly, and by small inspirations. In this way the respiratory muscles and the lungs, being accustomed to a certain rhythm of movement, keep it notwithstanding any nervous shock which the system may sustain; even the acceleration of the circulation which is an ordinary effect of emotion, soon finds in a methodical inspiration, an obstacle to which it must yield. Regulated by the breathing, function after function returns to its natural condition; the heart ceases to palpitate, the brain becomes clear and the voice docile; while on the contrary if any disorder of the breathing be added to the effect produced by emotion upon the cerebral system, it becomes impossible to control the action of the voluntary muscles.

Besides the precautions we have mentioned, the singer must remember that many things which may seem to him trifles, if persevered in, will finally affect the voice. Thus by habit, the voice may be modified or even changed. Sailors, smiths, and others who are engaged in noisy occupations, exert their voices more strongly than those having quiet pursuits, and thus change the intonation of the voice.

The attitude also affects the voice. When the individual stands erect the movements of both the respiratory and the vocal apparatus are most free and effective; the larynx, by the erect position of the head, is carried forward; the arytenoid cartilages are also so

placed that a slight tension of the vocal chords is produced, so that every thing in this position conduces to the formation of clear and harmonious sounds.

We have already spoken of the compression of the neck. Let, therefore, the dress of singers be loose, so that too great a flow of blood to these parts shall not be produced.

The singer, on account of the great amount of labor which his lungs are called upon to perform, might with benefit to himself abstain from all violent exercise, such as running fast, loud reading, etc. He should remember that the lungs already perform almost all the work which they are capable of doing, and not endanger his voice, if not his life, by taxing them unnecessarily.

The power and elasticity of the lungs may be developed to a wonderful degree by a very simple exercise. This consists of four parts, which should be successively and perseveringly practised; they are:

1st. To inspire as slowly as possible until the lungs are filled as completely as they can be.

2nd. To expire the air so introduced with the same, or even a greater degree of slowness.

3rd. To fill the lungs with air, and retain them so filled during as long a time as possible.

4th. To empty the lungs as completely as possible, and retain them in that condition as long as the strength will permit.

These exercises, which will be found very fatiguing at first, should be executed separately, allowing quite an interval to elapse between any two of them, so that the lungs may not be taxed too greatly. The first two,

viz., the slow inspiration and expiration, can be executed with greater ease and regularity if the mouth be almost closed, so that a very small opening only is made for the passage of air.

Before closing this chapter, let us return again to what we have said of singing as a hygienic means.

From the manner in which the singer is compelled to breathe, the lungs are often filled completely with air, and thus the lungs increase in volume; the trachea and the osseous walls of the chest also partake of this development; the voice gains in volume and strength; the circulation becomes more active and the functions of the various organs of the body are thus better performed than before. Provided, then, that we violate none of the laws which are necessary to our well-being, a moderate use of the vocal organs tends to maintain the general health, or even sometimes to promote it. Very frequently it has happened that a narrow chest has acquired a happy development through the judicious and continued exercise of the vocal organs.

But the singer must bear in mind that singing has its disadvantages as well as its advantages. He should never forget that if the singing be kept up for too long a time or be repeated at very short intervals, the continued movements to which it gives rise may act injuriously, not only upon the larynx, but also upon the organs contained in the thoracic and abdominal cavities. The list of difficulties which may be brought on by an immoderate exercise of the vocal organs is long. First in the order of frequency, we must notice hoarseness and dryness of the throat, due

to the exhaustion of saliva; a sensation of prickling in the larynx; a more or less diminution in the range of the voice, or sometimes a change in its timbre, caused by a lesion of the larynx; laryngeal phthisis, or *throat consumption*, a deposit of tubercles in its coverings; œdema of the glottis, or serous infiltration of those parts of the larynx especially concerned in the formation of the voice; finally consumption itself may be the effect of the great labor entailed upon the lungs.

Sometimes the production of very high notes requires considerable efforts, which cause the blood to ascend too violently to the face; congestion and cerebral hemorrhage have at times followed. The lungs, during the acts of singing or declamation, are unable to properly aerate the blood, on account of the constant action they are called upon to perform. It results from this that the blood is no longer oxygenated, and therefore tends to accumulate in the nearest blood-vessels, fills beyond measure the cavities of the heart, and predisposes to aneurismal dilatations.

These results of excessive use of the vocal organs show how careful and moderate an exercise should be allowed to people subject to hemorrhages from the organs of the chest or inflammation of the organs contained therein, while singing should be entirely forbidden to those suffering from consumption or heart-disease, lest it aggravate their trouble.

Our last hygienic measure, and a very important one, is that the moment the singer is troubled with a short, dry cough, a profuse expectoration, a gradual

loss of flesh, or spitting of blood, it behooves him to cease singing, in order that by giving his overtasked organs rest, he may allow them an opportunity of recovering their strength, and he himself his health.

APPENDIX.

APPENDIX.

As we have seen in the preceding pages, a very slight cause may determine a sore throat. Passing from a well heated ball-room or theatre to the exterior air without taking the precaution to cover the body sufficiently; getting the feet wet or chilled; remaining for a few minutes in a damp room; forgetting the use of a purge long indulged in; the suppression of menstrual or hemorrhoidal discharges, of perspiration, especially of the feet; the fatigue produced by reading, singing, or declamation; the use of iced drinks, of irritating food, such as pepper, cloves, dry fruit, nuts, almonds, etc.; indulging in strong liquors, or finally an hereditary disposition, are all predisposing or determining causes of inflammatory sore throat.

But generally the inflammation is restricted to the uvula and the tonsils. When the latter are involved, they may become greatly enlarged so as to interfere with or even render deglutition almost impracticable. The articulation of words becomes impossible and even respiration is carried on with great difficulty, so that often the patient for the moment is unable to inspire at all. If the uvula is involved, liquids are more difficult

to swallow than solids, and the grievous state of the sufferer is rendered still more so by the continued efforts to swallow provoked by the uvula tickling the base of the tongue.

The uvula, commonly called the palate, is suspended in the central portion of the veil or arch of the palate forming an integral part of it. Its functions are: (1) to aid in the straightening of the veil of the palate; the fleshy fibres of which it is mostly made up allowing it to contract completely upon itself, and so to carry the veil of the palate upward. It also aids to draw the pillars closer to each other in the median line. (2) At the anterior and superior portions of the uvula is a gland the duct of which is sometimes visible and whose office is to keep moist the bucco-pharyngeal region. (3) The uvula closes completely the posterior opening of the buccal cavity.

When inflammation sets in, the engorged portion is no longer under the control of the azygos muscle —a small muscle forming the substance of the uvula— and relaxation and lengthening of the uvula take place, and a portion remains hanging down between the pillars. What is the result? Besides the disagreeable sensation occasioned by the irritation produced by the point of the uvula touching the base of the tongue, and which causes a continual desire to swallow, it interferes in a great measure with the production and modification of sounds. It may even by the continued irritation produced, be the exciting cause of chronic sore throat or of laryngeal phthisis.

The constant tremolo we hear in some voices, and

which some singers with bad taste endeavor to cultivate, should rather be called *tremor* than tremolo, resembling as it does the voice of the aged. In many cases I traced this trembling to a relaxation and prolongation of the uvula; the organ remaining hanging loosely is shaken by the air during the emission of the sound. The tremor always entirely disappeared when the parts were restored to their normal condition.

The tonsils, two small ovoid bodies, are situated at the origin of both the respiratory and digestive tubes. They secrete a semi-transparent liquid, whose function is to lubricate the mucous membrane lining the pharyngeal region, so as to render it softer, and facilitate the movements of the parts during singing, speech or deglutition. Though they do not in any way contribute to the production of sound, yet if we consider that the passage of air during inspiration tends to dry the vocal organs, their importance will be readily admitted. But they may be too voluminous, and in that case they will exercise a bad influence upon the quality of sound, or they may even interfere with its formation. Their enlargement gives rise to a particular tone of voice, in the formation of which both the guttural and nasal timbres concur. Besides this, they impede deglutition, the respiration becomes noisy and laborious, especially during sleep, and pressing against the opening of the Eustachian tube, which is behind them, consequently oppose the renewal of air in the internal ear, and thus produce what is termed throat deafness; a very grave thing for the singer, who needs so much to hear himself and others.

Amongst the most marked effects of enlarged tonsils may be noted the derangement of health, and in young persons the arrest of development. Dr. Yearsley, who has observed the fact in numerous instances, says that it is probably to be accounted for —

1. By the enlargements exerting more or less pressure on the carotid artery, thus imposing an obstacle to the ready flow of blood to the brain, by which the nervous energy of the body is diminished and corporeal development is retarded. Any impediment to the due transmission of blood to the brain, must exercise a prejudicial effect upon the nervous system.

2. By the food in its passage to the stomach becoming imbued with the foul secretions poured out from these diseased glands; for, if the food does not reach the stomach in a state of purity, that organ becomes disordered, and the general health suffers. From the lacunæ of enlarged tonsils issue foul secretions, which taint the food in its passage down the throat to the stomach: the body therefore must be deprived of its due supply of pure and wholesome nourishment.

3. By the air which the patient breathes becoming tainted on its passage to the lungs, and thus producing an effect identical with that of living in an impure atmosphere. The air which the sufferer from enlarged tonsils takes into the lungs in the act of breathing, is vitiated by having to pass over a diseased condition of the throat; consequently it is tantamount to the patient living in an unwholesome atmosphere, or an unhealthy and unsuitable climate.

On the tonsils themselves the enlargements react

in a very injurious manner. The large size and low organization of the glands renders them very liable to repeated attacks of acute or sub-acute inflammation. Patients with enlarged tonsils are often so susceptible, that inflammation of those glands follows the slightest exposure and comes on with the mildest catarrh. These frequent attacks of quinsy not only cause much suffering and augment the size of the tonsils, but when the already hypertrophied glands become still further enlarged by inflammation, there is often risk of suffocation. It may be well to bear in mind, also, that *the danger of scarlatina, diphtheria, croup, and laryngismus stridulous, is, of course, greatly increased* by any pharyngeal impediment to respiration. *The extremely disagreeable intonation of voice* caused by enlarged tonsils sometimes makes an effort to lessen the defect very desirable. The voice is sometimes nasal in its tone, sometimes merely thick or muffled, more rarely guttural. This peculiarly unpleasant modification in the voice is often so serious a drawback to young people, as to make them very anxious to overcome it. Snoring is another objectionable peculiarity, sometimes caused by enlarged tonsils. (Morell Mackenzie, 1864, page 4.)

The aid of the physician or surgeon being often called in to remedy the injurious influence these organs, small as they are, exert when diseased, not only upon the voice, but, as we have seen, upon the general health, surely I may be permitted to express here my views concerning a method, which, unfortunately, notwithstanding its unsatisfactory, nay, its positively evil results, is yet too much practised. I allude to the

excision or removal of the tonsils or uvula by the knife.

This practice has strong advocates, I am aware, but I have the lessons of experience and the support of good authorities.

"The experience of the most successful practitioners and my own, has convinced me that the partial or complete excision of the tonsils may cause an hemorrhage which it is sometimes difficult to remedy; fits of coughing, fainting, spasms, suffocation, are the accidents which accompany it. . . . . As for the excision of the uvula, it is not without its difficulties; we know that it cannot be seized without trouble, and without occasioning more or less intense pain. Finally the extirpation of the tonsils, and the cutting off of the uvula, so often practised upon singers and dramatic artists, is never crowned with satisfactory results. In the most satisfactory cases, the part attacked by the scalpel becomes so very irritable that the least change in temperature, a forced declamation, and especially sustained singing or speaking, are sufficient to produce an *angina* which I have often seen extend to the pleura and lungs." (Bennati, Etudes sur la Voix Humaine, p. 180.)

There is a case mentioned by Portal, in which a skilful surgeon, in scarifying the tonsil of his patient, wounded, as he supposed, some ramification of the internal carotid, and the patient was presently dead. (Science and Art of Surgery, by John E. Erichsen, page 880.)

Columbat, although doubting the statement of

Wedel, that "the loss of the uvula causes the food and liquors to ascend the posterior orifices of the nasal fossæ," admits that the operation may induce the nasal mucus to fall more readily in the throat, and also that the emission of acute notes may be rendered more difficult by the excision, which he condemns unless all other means have failed, or when the extraordinary tumefaction of the tonsils may endanger the patient's life. (Maladies des Organes Vocaux, page 134.)

Harvey states that the removal of the tonsils interferes with the development of the genital organs.

An eminent physician, Dr. Ed. Fournie, says that "that operation (excision of the uvula), small as it is, may affect the general health." (Etudes Pratiques sur le Laryngoscope, page 54.)

Finally we may sum up the above authorities, and say with Dr. Morell Mackenzie of London, that the obstacles to the surgical extirpation of the tonsils are: (1) its dangers; (2) its difficulties; (3) the objections to it entertained by many patients.

There are, it is true, certain anatomic conditions which may necessitate the use of the scalpel. Tumefied or much ulcerated tonsils may require excision; but when simply enlarged they may be brought back to their normal size by a few applications of either the Vienna paste or the Bichromate of Potassa. It needs a little more time to reach the result, but it is much more certain and complete.

I append here a few of the cases of enlarged tonsils and elongated uvula which I have treated in that manner.

Case I.—Mr. Wm. D., æt. 19, had always enjoyed excellent health until towards the close of March, when without any appreciable cause, he was seized with so severe an attack of bronchitis, that all remedies seemed powerless to arrest it. His complete loss of appetite, emaciated physical weakness and night sweats, were a cause of alarm not only to his parents but to his physician. In this condition he called to see me. He had a severe cough, abundant thick grayish expectoration, attacks of fever in the evening and night sweats. There was no appetite, and his strength was almost gone. Auscultation revealed loud sibilant rales in the smaller and mucous rales in the larger bronchii with a feeble respiratory murmur. The examination of the throat showed both tonsils so greatly hypertrophied that at times they threatened suffocation. As the chief trouble then seemed to be in the throat I applied to the tonsils the Vienna paste—altogether four applications were made at intervals of five or six days. The second application seemed to afford relief, and after a two months' tonic regimen he regained his former strength and freshness.

Case II.—Adele F., of Jersey City, a child of 8, had repeated attacks of coughing and was subject to severe sore throat whenever she was exposed to cold. The fits of coughing generally came on towards evening, and during the night kept her awake. Irritation of the uvula seeming to be the cause of her trouble, the paste was applied to it twice within a fortnight, when the cough and sore throat both disappeared.

Case III.—Miss J. F., of St. Louis, who was

studying to become a dramatic artist, came to consult me, stating that she was subject to repeated attacks of ulcerated sore throat, and that lately she was obliged to discontinue her studies on account of her voice, which had become thick and harsh. An examination with the laryngoscope showed that the tonsils were much enlarged and of the volume of a medium-sized walnut. Both tonsils were touched with the paste five times. To-day they are of normal size and the dysphonia and hoarseness have entirely disappeared.

Case IV.—I was consulted by Mr. Carl R., of West 12th St., a tenor singer, concerning a difficulty which he experienced in singing the higher notes. I examined the vocal organs with great care, but could detect nothing except considerable elongation of the uvula to account for the alteration of the voice. The uvula was cauterized twice during the following ten days. So marked an improvement followed that Mr. R., who for some two years had not been able to sing above F on fourth line, now reaches A with ease.

Case V.—Mr. J. W. B., of Tennessee, came to me complaining of an alteration in his voice. He was also troubled with partial deafness and a constant buzzing in the ears. The vocal organs were seemingly perfect. The tonsils, however, especially the right, were very large. Attributing to this not only his dysphonia but the trouble in hearing, I proposed cauterization. This was performed three times on the left and five times on the right tonsil, and to-day, two years after the application, the tonsils have almost entirely disappeared, as have also his deafness and dysphonia.

Case VI.—Miss G., of Hoboken, a music teacher, of a nervous temperament, was seized with a hoarseness that became worse towards evening, and especially so after any vocal exercise. Her physician had recommended excision of the uvula, to which she would not consent. She, however, allowed me to cauterize it. The paste was applied twice, and she can now easily go through with the prolonged and fatiguing exercises which her profession demands.

Case VII.—Jno. C. R., a law student, 18 years of age, came to consult me for a difficulty in speaking which had existed for some six months. When I saw him there was a complete loss of voice, a constant cough, and night sweats. Auscultation showed that the chest was normal. By means of the laryngoscope the left vocal chord was seen to be somewhat swollen, the tonsils to be greatly enlarged, and the uvula so elongated as to fall down into the pharynx. The Vienna paste applied to the uvula caused an immediate contraction of that organ. Mr. R. coughed several times, then spoke for the first time in 22 hours. Subsequent applications to the uvula and tonsils, if they did not restore the latter to exactly their normal size, developed a new condition in them so that the dysphonia has entirely disappeared.

Case VIII.—Anna C., of East 28th St., is only 6 years of age, and has such large tonsils that they meet in the median line. Her family physician had for a long time urged the excision of the enlarged tonsils, but the mother would not hear of it. Finally, the entreaties of her friend Mrs. Holt, of Brooklyn, induced

her to bring the child to me. Two applications only of the Vienna paste were made, and with such good results, that no further reduction seems necessary.

Case IX.—Mrs. W. This lady is in the enjoyment of tolerably good health, except that every winter she is troubled with a sore throat and partial loss of voice. During one of these attacks I was consulted. Laryngoscopic examination showed the mucous membrane of the throat to be red and swollen, the uvula procident and hypertrophied. Deglutition of aliments, especially liquid, was very painful; so much so as to be almost impossible. At the time, she spoke only in a whisper. Two applications of the paste were made to the uvula and a gargle was ordered, the use of which she was to continue during a month. Last winter, the first one in four years, she was entirely free from sore throat.

Case X.—Miss Hattie L., of 42d St., aged 21, of a nervous temperament, caught cold by leaving a ball-room, in March 1868. This was followed by a violent sore throat which confined her to the house for some two months. By the end of May she had so far recovered, except her voice, that her physician, Dr. B., advised her to go to the country in the hope that as she regained strength, her voice would return. His expectation was in a measure verified, but she could no longer use her voice in the upper register. I then saw her. There was a redness and swelling of the pharyngeal mucous membrane, the tonsils were greatly enlarged and the uvula much elongated. The Vienna paste was applied twice to the uvula, three times to

the tonsils, and to-day Miss L. says her voice is stronger than it was before her illness.

Case XI.—I was consulted in 1866 by a Mr. C., a bass singer, formerly a pupil of Sig. Rondinella, for a sore throat, which had already existed for several years. The voice was harsh and veiled—though there was no cough, the expectoration was frequent. Examination revealed only redness of the throat and elongation of the uvula, to which I applied the paste twice. Within a few months the timbre and range of his voice had very much improved.

Case XII.—Miss P. of Athens, Pa., 13 years of age, was sent to me in the beginning of November, 1868, by her uncle, a banker in Pa., who was then a patient of mine. For years she had suffered from sore throat. She was pale and chlorotic, had little or no appetite, and remained in a dreamy, listless state until the middle of each day. Her tonsils were enlarged to such a degree that she had generally more or less difficulty of breathing, and sometimes this was so aggravated that she was threatened with suffocation. I applied the Vienna paste to the tonsils twice, and then permitted her to return home. In a letter dated the 2d of December, she says: "We reached home Thanksgiving evening; I have had a good appetite, and have eaten everything every day since, and I must tell you that my usually cold feet and hands are warm now nearly all the time, which surprises and delights us all."

I have seen little Miss P. since, and find her general health very much improved.

I will not weary the patience of the reader by further details of cases, which must of necessity closely resemble one another. The few that I have already given, selected from a great number, because in them no constitutional medication was called in to aid the local treatment, will, I trust, be sufficient to fully illustrate the advantages which this method of reduction possesses over the use of the knife. Besides being free from the dangers attendant upon the old method of excision, the reduction by the paste produces no roughness, no irritable condition of the parts, the natural result of the former operation, and renders them less liable to the influence of sudden changes of temperature.

There is another subject on which I am often consulted, and which from its importance needs careful consideration.

We see daily people who though having strong, sonorous and flexible voices, are yet unable to sing correctly; this is popularly denominated "having no ear for music." Bennati's view of this subject is, that this inability is due to physical discordance between the ear and those organs which, having their seat in the larynx, produce and modify the voice. This discordance is a neuralgic trouble, arising from a want of proper harmonic relation between the actions performed by the vocal organs and those imposed by their action upon the auditory nerves. This explains why it is that people having strong and flexible voices, yet sing out of tune; the defects of their voices, if there be any, are due to the form, the energy and disposition of the organs themselves, whilst a faulty intonation results

from the fact, that the nervous system of the ear, since it does not coincide with the nervous system of the vocal apparatus, rests upon different relations to the sound produced, and is therefore affected in proportions which have an increasing tendency to disturb one another's action.

Outwardly the ear presents but little to be noticed. The secret of its power lies in the most hidden portion. Anatomists for a long time studied only those parts concerned in the transmission of the sonorous wave, to the fluid contained in the membranous labyrinth upon which the terminations of the auditory nerves are distributed. By the external auditory canal the sound reaches the tympanum and thence by a very complicated path passes to the Labyrinth; within this is enclosed the Cochlea, where it plays upon the nervous keyboard. This is formed by a spiral membrane of great delicacy, upon which the nerves are distributed, and which is bathed by a liquid within the small osseous cavern of the Labyrinth. The microscope has proved this membrane to be composed of about three thousand small fibres, the filaments of the acoustic nerves; the extreme delicacy of these nerves enables the ear to detect with wonderful facility the various sounds.

Hence the conditions which must be fulfilled, in order that the voice may have a correct intonation, seem to be: First, that there shall be an aptitude for music; secondly, that the cerebral substance in which the sound is to be registered be in a normal condition; thirdly, the absence of all lesions of the auditory nerve which transmit the sounds to the brain; fourthly, ab-

sence of all grave affections of the ear; fifthly, that the organs of the voice themselves be in a perfectly healthy state; and sixthly, that the proper relation of ear and voice exists.

We meet constantly people whose auditory and vocal apparatus are perfect, but in whom there is a lack of musical aptitude; so also we sometimes meet with people who have been noted for the excellence of their voice, the acuity of their ear, and who have lost the last from an inflammation of the internal or middle ear, or a local apoplexy; often they recover it with the cure of the trouble. There is another class, who though they understand thoroughly all that harmony requires, are yet unable, on account of hoarseness, or of an ulceration of the throat, to give to each note its proper intonation. The difficulty may also arise from a discordance between the pitch of the sound, the energy of the modifying organs, and the volume and rapidity of the breathing.

We find, then, that the conditions necessary to a true intonation are very varied, and that the means which must be employed to remedy any defect thereof, must necessarily vary according to the cause of the difficulty.

THE END.